Foreword

15 April 2006, Samreboi, Ghana.

As part of the final year of our study Tropical Forestry at Larenstein University of Professional Education in the Netherlands a practical assignment has to be completed culminating in a thesis. We travelled to Ghana to work for Samartex Timber and Plywood Company Ltd. in the Western region of the country. Through a friend working for FORM international, a Dutch business relation of Samartex, we were able to establish communication with Gilmour Dickson, General Manager at Samartex Timber & Plywood Company ltd. After communication with Mr. Dickson and negotiation with our professor, a practical work placement of 3 months was agreed upon. At first there was talk about the production of a training video concerning Reduced Impact Logging but eventually there proved to be more need for the construction of a forest management plan for one of the operational forest reserves leased by Samartex Timber & Plywood Company Ltd. After 3 months of predominantly preparations and fieldwork on site in Ghana, the final management plan was finished in the Netherlands. With this report we hope to have contributed to the improvement of forest management in Ghana. The first two chapters were mainly included to give general information for people not very familiar with forestry in western Ghana. They should probably be skipped by SAX but can be considered useful for Larenstein University. In addition to this report and appendix, a wildlife field guide is also presented as extension material. These documents together with a presentation in a colloquium at Larenstein University, are intended to prove that we meet the requirements for BSc graduation in the field of Tropical forestry and Nature management.

Roy Mol and Sil Westra

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Summary

In order to conclude our course BSc Tropical forestry and Nature Management at Larenstein University of Professional Education we took on the assignment to write a forest management plan for Mamiri Forest Reserve; one of the concessions leased from the Ghanaian government by Samartex Timber and Plywood Ltd. based in the western region of Ghana, West Africa. Mamiri Forest Reserve is a narrow north-south elongated forest reserve with an area of roughly 45 km². It is one of three reserves included in Forest Management Unit 10. The flat southern half of the reserve consists out of WE forest, while the northern, hillier area is covered in ME forests. It is one of the forest reserves that encompasses the transition zone of these two evergreen forest types.

In 2001 the Ghanaian government implemented a new national management strategy and divided the northern area of Mamiri Forest Reserve into two new conservation areas, Globally Significant Biodiversity Area and Fauna Protection Area. This area is known to be inhabited by chimpanzees. The southern area is reserved as Timber production area.

Samartex has no clear plans for Mamiri Forest Reserve and does not intend to exploit the reserve on the short term. Because of its steep slopes, swamps and conservation areas, half of the reserve is unsuitable for timber exploitation. Looking to the future Samartex realizes that commercial timber exploitation is not economically sustainable and is looking for alternative income. It realises that ecotourism has reasonable potential as a source of income and is turning its eye towards Mamiri Forest Reserve. Because of the accessibility of Mamiri Forest Reserve, this is regarded to be an option for future management.

The Ghanaian Forestry Commission has written a management plan concerning Forest Management Unit 10 in 2001. However, it only describes general management issues and does not include detailed information and proposals concerning wildlife, ecotourism or silviculture. Samartex has asked us to write a new management plan with more emphasis on these issues and specifically aimed for Mamiri forest reserve.

First of all a lot of data has been gathered to get a good view of the reserve in terms of natural resources. With help of a botanist nine permanent sample plots of one hectare were established evenly throughout the forest to produce continuous data about the current timber stand. All trees above twenty centimetres diameter were measured and five-by-five meter regeneration plots were set out where all growing plants were noted. Results have proven that the present timber stock is too meagre for timber exploitation, simply because numbers of economical attractive species with adequate diameters are low. Regeneration of economic species is also very little. Furthermore, the high conservation priority black star species are abundant which makes exploitation practices difficult. Although important data was gathered here, the nine PSP’s should be reassessed every three years so that annual increment, mortality, and changes in species composition can be monitored.

To be able to get information concerning fauna and non timber forest product collection within the short time frame, local people living in the vicinity of the reserve were interviewed. Hunters were shown pictures of animals thought to be present in the reserve and they were asked whether they had seen or hunted them before. Local herbalists and households were asked to name the two most important NTFP's in different categories. Results show that some (critically) endangered animal species like the chimpanzee (*Pan troglodytes*), white breasted guinea fowl (*Agelastes meleagrides*) and the bareheaded rock fowl (*Picathartes gymnocephalus*) are still present within Mamiri Forest Reserve. However, it is very clear that virtually all animal species are hunted for their meat and populations are declining. What is also quite remarkable is that species seem more abundant in the northern part of the reserve. The interviews also showed that there is a virtually endless list of NTFP's which are used by the local people. The forest provides them with a broad diversity of products, ranging from food, stimulants and medicines to tools and construction materials.

The nine one-hectare permanent sample plots that were established have shown that the area is not profitable for timber extraction and that the northern half of the reserve has a high biodiversity and should remain under conservation restrictions. Because of the presence of the different significant endangered animal and plant species as well as a very good accessibility as it is located along the Asankrangwa – Manso Amefi main road, the northern area has a high potential for ecotourism and ecological research. Chimpanzees could very well function as a flagship species to attract conservation organisations, researchers and tourists. Local hunters could be trained to habituate chimpanzees to humans and function as guides to take tourists on forest walks or assist researchers. However, the hunting problem needs to be addressed by the government as this is a major concern at this point in time. Alternatives such as domesticating wild animals for food provision should be stimulated and environmental laws should be adequately enforced. Mamiri Forest Reserve contains some steep hills which could be a suitable starting point for the construction of a canopy walkway. This would also be a major tourist attraction.

The southern parts are less of interest for tourism, as these areas are more remote, and severely affected by human influences. These areas are very suitable for research such as experimental silvicultural methods that could be used in other concessions in a later stage.

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Abbreviations

AAC	Annual Allowable Cut
AT&P	African Timber & Plywood Company
CI	Condition Index
CITES	Convention on International Trade on Endangered Species
DFM	District Forest Manager
DRH	Diameter Reference height
EAP	Environmental Action Plan
FAO	Food and Agricultural Organisation
FC	Forestry Commission
FRMP	Forest Reserve Management Plan
FMU	Forest Management Unit
FPA	Fauna Protection Area
FSD	Forest Service Division
GHI	Genetic Heat Index
GIS	Geographical Information Systems
GPS	Global Positioning System
GSS	Ghana Selection System
GSBA	Globally Significant Biodiversity Area
IUCN	The World Conservation Union
ITTO	International Tropical Timber Organisation
MDL	Minimum Diameter Limit
ME	Moist Evergreen (Forest)
MFR	Mamiri Forest Reserve
NFSI	Natural Forest Stand Improvement
NP	National Park
NTFP	Non Timber Forest Product
PSP	Permanent Sample Plot
SAX	Samartex Timber and Plywood Company Ltd.
TIDD	Timber Industry Development Division
TPA	Timber Production Area
TSS	Tropical Shelterwood System
TUC	Timber Utilisation Contracts
WE	Wet Evergreen (Forest)
WD	Wildlife Division

m^2	Square metre
m^3	Cubic metre
Km^2	Square kilometre
Cm	Centimetres
Ha	Hectare
C	Common
UC	Uncommon
R	Rare

Introduction

Ghana has an enormous wealth of natural resources, including tropical hardwood timber and many other forest products. Under English colonisation in the beginning of the 20th century the, then, Gold coast government began to declare certain lands subject to forest reservation to be able to manage their natural resources. The natives, however, remained to be the lawful owners of their own ancestral lands. In the early 70s, as a result of political conflict, all rights over their ancestral lands were stripped form the traditional communities and assumed by central government (Repetto in Parren & de Graaf 1995). The outcome was that traditional communities lost the incentive to maintain forest resources and an ever increasing deforestation of unreserved forest lands took place (Parren & de Graaf 1995). Furthermore, Traditional sustainable slash and burn agriculture that has been practised throughout Ghana for many years has become unstable over the past few decades. Due to population pressure more and more forest is being burnt. As fallow periods are reduced the little regeneration that is burnt can no longer provide adequate soil nutrients. In the off reserve areas many grounds are also converted into plantations for production of cash crops such as cacao. It may be clear that with the disappearance of the forests a wealth of natural resources are lost for ever.

Nowadays there is hardly any healthy off reserve forest left and people have become dependent on designated forest reserves for collection of many natural resources. The pressure on these reserves is ever increasing. For a timber company like Samartex Timber & Plywood Company Ltd. (SAX), which leases these reserves from the Ghanaian government for timber exploitation, this does not make things easy. Since the Forestry Commission (FC) established Globally Significant Biodiversity Areas (GSBA's) and Fauna Protection Areas (FPA's) next to Timber Production Areas (TPA's) within many forest concessions and obliged the concessionaires to manage these conservation areas things have become rather complicated.

To be able to manage an area with so many interests by different target groups and ensure sustainability of natural resources -let it be for wood production, hunting, gathering or ecosystems and their flora and fauna- within forest reserves is a big challenge; many things have to be taken into account. This report tries to help accomplish adequate management concerning one of the operational forest reserves leased by SAX, namely Mamiri Forest Reserve (MFR).

MFR is a narrow north-south elongated forest reserve with an area of roughly 45 km². The flat southern half of the reserve consists out of wet evergreen (WE) forest, while the northern, hillier area is covered in moist evergreen (ME) forests. It is one of the forest reserves that encompass the transition zone of these two evergreen forest types. Altitudes in the area lie between 90 and 180 meters and the total area is covered by a network of small streams. The north is crossed by a main tarmac road and the entire area is easily accessible by car. MFR is surrounded by small rural villages in which cacao plantations and the trade and use of some forest resources are the main source of income.

1. Forestry in Ghana

Currently Ghana is recognised as one of the most advanced tropical African countries in established forest policy, legislation, forest inventory, management planning, and in having a National Forest Standard and principles, criteria and indicators for judging the quality of forest management and usage (Timber Industry Development division, Ghana Forestry Commission 2006).

1.1 Ghana's forestry history in brief

Logging activities in West Africa can be traced back as far as the 16th century when samples of timber were sent to the United Kingdom. In the next few centuries other forest products like kola nuts, wild rubber and palm oil were also principle export products next to slaves and gold. Around 1833 the first trunks of African mahogany appeared on the British market and from 1878 onward their importance increased. Forest exploitation resembled an operation similar to salvation felling and took place in unreserved forest since forest reservation in Ghana was initially aimed at the conservation of forest lands and not at timber production. The British colonial administration of Ghana attempted to regulate forest exploitation by handing out concession rights and implementing regulations to avoid destruction of this renewable resource (Taken from Parren & de Graaf 1995).
In 1906 legislation was enacted to control the felling of commercial tree species, followed by the creation of the Forestry Department in 1908. The demarcation and reservation of the forest estate was largely completed by 1939 and a forest policy was adopted in 1948. After the formation of the Department of Game and Wildlife in 1965 wildlife reserves and conservation regulations were first gazetted in 1971 and the wildlife Conservation Policy was published in 1974 (Taken from Ministry of lands and forestry 1994). The reconstituted FC came to life after the adoption of the Forestry and Wildlife Policy of 1994. For the first time joint management between forestry and wildlife was implemented and administered by one governmental organ.

1.2 Forest administration

The Ghana Forestry Commission consists of three operational elements:

- Forest Services Division (FSD)

  The FSD is responsible for forest reserve management throughout Ghana. It has the task to enforce forest laws and to make sure that stakeholders such as locals and timber companies obey rules and regulations.

- Wildlife Division (WD)

  Known as the Department of Game and Wildlife before 1965, the WD changed to her current name after the adoption of the Forestry and Wildlife Policy of 1994. In the intervening, the Department moved from the Ministry of Forestry to the Ministry of Lands & Mineral Resources, Lands & Natural resources to the present Ministry of Lands & Forestry. It is responsible for all wildlife in the country and administers 16 wildlife-protected areas (PAs), 5 coastal Ramsar Sites and the Accra and Kumasi Zoos. It also assists with the running of 2 community owned Wildlife Sanctuaries (based on Wildlife Division, Ghana Forestry Commission, 2006)

- Timber Industry Development Division (TIDD)

  The TIDD works in support of the logging and wood processing sector. It encourages a skilled and progressive industry based on the sustainable use of forests and providing a source of secure employment, income, career and skills development (Timber Industry Development division, Ghana Forestry Commission 2006).

The headquarters of the FC can be found in Kumasi & Accra.

1.3 Policies and legislations

1.3.1 Forest and wildlife policy

The forest and wildlife policy (Ministry of lands and forestry 1994) has been developed in 1994 to outline the principles, aims and objectives which are meant to guide the sustainable development of both forestry and wildlife sectors. In the following chapters a short summary is given of the complete document. Refer to Ministry of lands and forestry (1994) for full details.

1.3.1.1 Guiding principles

In enunciating the forest and wildlife policy the Government of Ghana recognises and confirms many guiding principles. These guiding principles are based on national convictions and international guidelines and conventions and are embodied in the Constitution of the Forth Republic, the current development policies of the parliamentary government, the Environmental Action Plan (EAP) as well as agreements emanating from existing projects (Based on Ministry of lands and forestry 1994). The list of principles is to numerous to mention here but key issues are: local people, the nations viability, sustainable resource management, economic development, national accounting, incorporation of traditional resource management, appropriate legislation, retaining financial benefits to fund maintenance, benefit for local communities, consideration of forest and wildlife fees and taxes, transformation of current timber industry, addressing unemployment, participatory management, protection of forest and wildlife resources.

1.3.1.2 Policy statement

The Forest and Wildlife Policy of Ghana aims at conservation and sustainable development of the nation's forests and wildlife resources for maintenance of environmental quality and perpetual flow of optimum benefits to all segments of society (Ministry of lands and forestry 1994). Their main objectives are to:

- Manage and enhance Ghana's permanent forest estate and wildlife resources
- Promote the development of viable and efficient forest-based industries
- Promote public awareness and involvement of rural people in forestry and wildlife conservation
- Promote research-based and technology-fed forestry and wildlife management
- Develop effective sustainable development capability

1.3.1.3 Strategies

In pursuing each stated policy objective, the government will focus on the following priority issues:

- Permanent Forest and Wildlife estate
- Reserve expansion
- Management and Utilization
- Rehabilitation and Development
- Protection
- Viable Wildlife and Forest-based Industries
- Enabling Environment
- Incentives and Assistance
- Development of Domestic Markets
- Public Education and Participation
- Public Education
- Public Participation
- Relevant Research
- Ecological
- Economic Applications
- Extension
- Effective Capability
- Institutional Strengthening
- Capacity Building

1.3.2 Zonation of forest reserves

To adhere to the national forest and wildlife policy all forest reserves in Ghana were divided in 2001 into different management zones, namely GSBA, FPA and TPA. Their different management regimes are described in the following chapters.

Within the high forest zone there are 216 Forest Reserves legally demarcated and controlled, which were mostly established between 1920 and 1960. They cover about 17,000 square kilometres. Of these about 12,000 square kilometres are primarily productive forests for sustainable production of wood but including environmental safeguards. More than 4,500 square kilometres are regarded as protective reserves where special environmental, soil and water considerations apply. (Timber Industry Development division, Ghana Forestry Commission 2006). Off reserve areas are not demarcated and safeguarded for silvicultural use; they are used by the local population for traditional activities including farming, the collection of Non Timber Forest Products (NTFP's), hunting for meat and fuel wood collection. The future of trees outside Reserves has been a matter of concern.

1.3.2.1 Global significant biodiversity area (GSBA)

GSBA's are areas selected for their high biodiversity and that are of interest to the international community.

<u>Global objective of management:</u>
Protection of both flora and fauna in order to maintain the biodiversity for wider national and international interest.

The main management regimes for GSBA:

- A ban on all logging activities within the area, no trees can be felled
- Commercial NTFP collection is prohibited
- Collection of herbs, leaves, snails and dead wood for domestic use is allowed
- Collection of Canes, Rattan is prohibited
- Hunting is prohibited.
- Road and track development are not allowed.

The forest service division has the responsibility to uphold these laws, and the responsibility to monitor and report the quality of forest management.

1.3.2.2 Fauna protection area (FPA)

Areas identified by the WD as being critical to the preservation of habitat required for rare or important species.

Global objective of management:
The maintenance of natural habitats for critical species.

The main management regimes for FPA:

- No tree felling
- The collection of all NTFP's is not allowed
- No road and track development
- Floral and faunal abundance and biodiversity maintained or improved.
- The population of chimpanzees maintained or increased.

The WD and Forest service have the responsibility to ensure that no tree felling will be done. For this, the Forest service has to monitor and report the quality of the management. The community and the forest service have a joint responsibility to ensure that no one will enter the FPA.

1.3.2.3 Timber production area (TPA)

Healthy, productive forest with a mean basal area that is larger than 15m2 per hectare and does not fall into a permanent protection zone.

Global objective of management:
Sustainable timber production should be ensured.

The main management regimes for TPA:

- Sustainable production of timber to provide a perpetual flow of wood products, revenue, for the resource owners and to fund the forest management while maintaining environmental quality and social responsibility.
- Timber production should be roughly equal volume each year and as the forest moves into normality the area of forest logged each year should be close to 1/40 of the total coverage of the TPA.
- Tree selection should be based on fixed diameter limits for the different commercial timber species.
- A felling circle of 40 years is used to provide the forest some time to regenerate.
- Harvesting will be scheduled based on logging history and the state of the forest.
- Survey and yield allocation are executed in accordance with standards outlined in Manual of Procedures Section D.

Four to five compartments will be felled each year. The volume production in the past has been 400 to 500 cubic meters per compartment. Annual production is therefore estimated around 2000 cubic meter.

The Forest service has the responsibility to:

- protect, monitor and report quality of management.
- ensure that all payments for utilization are collected on behalf of the landowners and government, and receipts are properly maintained.
- control illegal encroachment in collaboration with the community,

1.4 Forest management

All timber harvesting operations in forest reserves must be properly planned. Planning for timber harvesting takes place at two levels; strategic and operational. Strategic planning is the responsibility of the Forest Service (Ghana forest service 1998).

1.4.1 Forest planning

Strategic planning is carried out by the Forest Service for the forest reserves in order to identify areas that are suitable for timber production; and to separately identify those areas that must be provided with some degree of protection or set aside for enrichment planting or plantations development. It does this through the production of Forest Reserve Management Plans (Ghana forest service 1998).
Timber Utilisation Contracts (TUC) are identified by the FSD compromising parts of a reserve, a whole reserve or indeed a group of reserves. Awarding and managing the implementation of TUC's, a series of operational plans are required at varying levels of detail. The FSD has set out the following steps to ensure proper planning and monitoring:

1. TUC contracts and specifications prepared by the FSD in liaison with land owners.
2. The contractor will produce a TUC area plan covering the whole TUC area as part of the contract selection process
3. The successful contractor will produce a TUC five year operational plan covering one coupe (or group) of compartments to be logged over a period of five years
4. The FSD/Contractor carries out a stock survey of compartments to be logged in the near future
5. Compartment plans covering a single compartment-the smallest area of management

(Based on Ghana forest service 1998)

1.4.2 Forest Reserve Management Plans (FRMP)

Forest Reserve Management Plans (FRMP's) are prepared by the FC and document the aims of management and the scheme of operations by which it is hoped to attain them. The forest management plan will provide details of the extent and composition of the forest resource, ownership issues and local rights, management zones (working circles) and their respective prescriptions (Ghana forest service 1998). The management plan that was prepared here gives more additional and in-depth information about MFR than the previous FRMP prepared by the FC's regional planning team in 2001.

1.5 Forest operations

The selective management system is basically what is supposed to be implemented in most of the forest concessions in Ghana where natural high forest is still present. Trees are selected based on diameter. Fruiting trees should be excluded from felling and a maximum of 3 stems can be felled per ha. Although research has proven that a felling cycle of 80 years is favourable, a cycle of 40 years is used to make sure that forestry is still profitable. For species that are under pressure (scarlet star species) a permit is needed before felling. Rare species (black star) should not be felled at all and felling is prohibited within 100 meters around the specimen. These regulations are implemented by the FC and they are responsible for enforcement of these regulations.

In practice productive forest reserves (or the productive portions of these reserves) are sub divided into compartments (usually 128 Ha). These 'compartments' are the smallest management unit, and harvesting is carried out within the confines of these compartments. The compartments in the reserves are grouped according to a harvesting schedule. The principle of this schedule is to manage the reserve on a forty-year rotation. This means that when a compartment has been logged it will be a further forty years before any further commercial logging can occur. This forty-year period has been chosen as the optimum period to allow natural regeneration to occur after logging. The individual compartments are grouped into coups within the harvesting schedule. Each coup lasts for five years. The company is allowed to log the compartments within the five years. The next coup cannot be entered into before the five years has elapsed. Ghana's logging standards are some of the strictest in the world. The number of trees removed per hectare (<2) is extremely small (Samartex 2006).

1.5.1 Exploitation regulations

To be able to limit exploitation and attain sustainability of closed canopy forest certain exploitation regulations were formulated by the FC. They are discussed in the next chapters.

1.5.1.1 Condition Index (CI)

The yield that can be taken from a compartment varies depending on the Condition Index (CI). The CI is a numerical expression of the condition of the under story within a compartment of the forest. It is an indication of the health and regenerating capacity of the forest. The Regional planning team (2001) noted that the forest condition of MFR was 3; meaning that for harvesting a reduced yield formula should be implied which states:

$$Z = 0.25\ y + 0.2\ x$$

Where:
z = Number of trees to be removed above felling limits.
y = number of trees in the diameter class equal to or above the felling limits.
x = Number of trees immediately below the felling limits.

Trees that have 5 or less stems in the diameter class directly below the felling limits should be excluded from felling. The number of trees removed should always be rounded down to the nearest whole number.

1.5.1.2 Annual Allowable Cut (AAC)

The annual allowable cut (AAC) is the maximum volume that can be felled every year without endangering the sustainability of the forest reserve. It is applied to 64 economic species, using a yield formula given by the FC and a rotation period of 40 years. Currently it is set at 500.000 m3 for the total of all forest reserves in Ghana.

The 64 economic species can be grouped into different star ratings, namely:

- 18 Scarlet star species which are now under threat of economic extinction, where the level of felling is greater than 200% of the sustainable level.
- 16 Red star species which are over cut and will be economically extinct eventually, the level of cut is between 50% and 200% of the sustainable level.
- 30 Pink star species from which, some are being exploited but none of them are endangered. The present level of cut is about 50% of the sustainable level.

The AAC from all forest reserves combined is shown in Table 1. The total of 683.100 cubic meters has been rounded down to 500.000 because most of the pink star species are not exploited most timber companies.

Species category	*Stems*	*Volume (m3)*
Scarlet star	5460	115900
Red star	15300	208700
Pink star	38660	358500
Total	59420	683100

Table 1: Annual allowable cut. (Source: Forest Development Master Plan, MLF, 1996)

An AAC for each compartment of an average of 128 Ha is defined, based on a 100% survey of commercial species. The harvestable area of a compartment is reduced by an average of 14% because of environmental or biological concerns (black star species conservation).

The AAC is based on all forest reserve areas in Ghana, covering a total area of 1.634.100 ha. About 762.000 ha has been allocated TPA within these reserves. The average annual stems and volume per hectare that would be allowed for felling can be calculated. As can be seen in Table 2 a maximum of about 35 cubic meters per hectare may be harvested from the forest in a 40 year time span.

Species category	*Stems/ha*	*Vol/ha (m3)*	*Stems in 40yr*	*Vol in 40 yr (m3)*
Scarlet star	0.007	0.15	0.28	6
Red star	0.02	0.27	0.8	10.8
Pink star	0.05	0.47	2.0	18.8
Total	0.07	0.89	2.8	35.6

Table 2: Annual allowable volumes

This is an overall number that is applied, however the number of trees that is allowed to be logged, is also limited based on the ecological region. For both ME forest and WE forest these numbers are identical. There is a limit of 3 trees per hectare. In the past this number has been exceeded slightly, but in the future they will be more actively adhered to (Ghana forest service 1998).

The national average mean tree volume calculated by the FC for commercial species is 10.75 m3. This indicates that the expected volume per hectare to be exploited from a WE/ME forest will be around 32 m3. This would be around 3,500 m3 for a whole compartment per 40 year cycle.

1.5.1.3 Minimum Diameter Limit (MDL)

Class I and Class II economical tree species are divided in Minimum Diameter Limits (MDL) of 50, 70, 90 and 110 centimetres respectively. Species divided amongst these classes can not be felled if their diameter is below the class they are in. They are applied and should be strictly enforced in all operational forest reserves. For reference refer to Appendix XX.

1.5.1.4 Ghanaian star rating system

A star rating system, based on the work of Hawthorne and Abu-Juam (1995), is used in Ghana to define the pressure on forested areas. All species are categorized and conservation status of each species is defined (Table 3). Factors that are used for categorization include distribution, ecology, local abundance, taxonomy, life history, interaction with ecosystems and economic importance (Hawthorne 1996).
Species that are endemic, rare, vulnerable, threatened, unusual or have low genetic resources are considered to be of greater value than other species. Forests that are

Relatively rich in these species are of more importance and should deserve more attention for conservation.

Star rating	*Specification*	*Genetic Heat Index*
Black star	Species endemic only to the area. No logging should occur within 100 meters near the specimen.	27
Gold star	Species endemic to the region	9
Blue star	Species that are widespread internationally but nationally rare or vice versa	3
Scarlet star	Common but under heavy pressure from exploitation. Exploitation should be managed well to sustain future survival	1
Red star	Common but under pressure from exploitation	1
Pink star	Common and moderately exploited	1
Green star	Widespread and not under pressure.	0

Table 3: Explanation of different star ratings

In addition to the star rating system, a Genetic Heat Index (GHI) is used. When the GHI is used to compare areas, the areas that represent the highest diversity of rare species will have the highest GHI. These sites can then be identified as biodiversity hotspots. The GHI method has been developed in the high forest areas of Ghana (Hawthorne 1996) and works well when more than 50 different species are recorded per site.

1.5.2 Silviculture

Silviculture can be defined as manipulation of forest vegetation to accomplish a specified set of objectives. It controls forest establishment, composition, and growth. Usually the main goal of silviculture is sustainable timber production, and in this point of view it can also mean cutting a whole stand of mature trees to open up the canopy. Some economically attractive species, like Azobe (*Lophira alata*), need large clearings for regeneration. Several different types of silvicultural systems have been tried, which all had different objectives. The whole procedure is based on the objective of the manager i.e. what final state of the forest he wants to achieve. Lamprecht (1989) mentioned three groups of forest objectives; the final state of the forest that the manager tries to achieve:

- Diameter based selective system without management
- Uniform high forest
- Selectively managed forest

The first objective can only be achieved in forests with very low species diversity. For this objective felling is only based on simple diameter limits. No inventory of regeneration is done and no domestication is needed; classic sustainable yield

regulations will be sufficient. This objective can be considered over optimistic, because it assumes that the annual increment of the forest is enough to provide in a sustainable yield.

The group with Uniform high forest as an objective, most systems are documented. These systems all aim at the conversion to a uniform high forest stand which is less labour intensive than the objective to “create” a selectively managed forest. Some of the known systems are the Tropical Shelterwood System (TSS) used in West Africa and the Natural Forest Stand Improvement (NFSI) used in Ivory Coast.

Selectively managed forest includes systems where some trees are selected for felling while most of the forest stand is left alone. Increment and the fulfilment of other (ecological) tasks can be continued. Stands under these management systems are mostly uneven in age, diameter and species composition. Tree selection is based on diameter, trees that slow the total increment of the forest and trees that can be missed for ecological reasons. A large part of the stand stays to fulfil other tasks within the forest and to increase in size. An example is the system developed by the Centrum voor Landbouwkundig Onderzoek in suriname (CELOS) used in Brazil which creates a more uniform system.

Two systems that have been used in Ghana in the past will be explained in short in the next paragraphs.

1.5.2.1 Ghana Selection System (GSS)

A silvicultural system that was used in Ghana from 1956 to 1971 is the Ghana Selection system (GSS). It can be seen as a system which aims for a selectively managed forest. The system was based on the assumption that a minimum of 23 potential crop trees in the diameter class of 10 to 48 cm were present per hectare.
It involves the stock mapping of all economic species that have a diameter of over 67 cm DRH, improvement thinning of immature stock and a selective felling. This method was used with the aim to create a predictable yield. The system had a felling cycle of 15 years which was later on prolonged to 25 years.
In the late 1960s the selection system was critically assessed on growth performance. The annual increment data for some economic species in the diameter range of 48-86 cm DRH of six forest reserves were compared. The results showed an average annual increment of less than 0.6 cm, which was regarded as being poor (Parren, de Graaf 1995). But when these numbers are compared with other similar forest areas in Liberia, they are not that low. The average annual increment in Liberian research had a maximum annual increment of about 0.6 cm after treatment.
Some doubts about the efficiency of the system arose because of the list of species that were used. Some of the species that were poisoned in the improvement thinning had in the mean time become highly economical species.
This shows that a forest should be well stocked with present economically attractive species, as well as the lesser economic species.
Regeneration of economical species was obtained but because of the lack of sufficient sample plots, this could not be demonstrated (Parren, de Graaf 1995).
The system had an average cost of 3.7 man days per hectare per year.

1.5.2.2 Tropical Shelterwood System (TSS)

This system was used in the moist semi deciduous regions where existing regeneration was insufficient and the number of potential crop trees was less than 23 per hectare. The main aim of the TSS, is to help ensure a successful regeneration of economically attractive species. The system uses some operations to open the canopy in order to induce regeneration and stimulate the growth of existing stands. This system is regarded as a monocyclic system as the entire marketable stock is felled at the same time. When regeneration is successful, the upper canopy, which functions as a shelter and a source of seeds, is removed. Only the small young trees in the stand are left. In this way a uniform high forest with a defined rotation and regeneration period is supposed to be created. The minimum diameter that shelter trees should have before being felled is 60 to 80 cm DRH. Because of the opening of the canopy rapid growth of pioneer species as well as climbers is encouraged and will smother the regeneration of desired species. To avoid this, weeding should be done six years before exploitation. Although regeneration is generally good under the TSS, the costs were very high, at 6.25 man days per hectare per year.

Ghana has used TSS on an experimental scale since 1947. It has been adopted in areas where it gave promising results. Here, the system concentrated on regeneration of *Meliaceae* like *Entandophragma spp., Guarea spp., Khaya spp.* and *Lovoa spp.* These species can produce a lot of seeds and the establishment of numerous seedlings is assured every year (Parren, de Graaf 1995). In 1969 the TSS was abandoned because of the number of treatments which made the system too costly.

1.6 Export of wood products

The Ghanaian government has prohibited the export of logs in the recent past to stimulate the processing of logs to take place in Ghana. This in an effort to stimulate growth of the Ghanaian economy. Fig. 1 shows the total value of wood export products in the past two years.

Fig. 1: Total value of Ghanaian wood export products (source: Ghana Forestry Commission 2006)

2. Mamiri forest reserve

Forest management unit 10 (FMU 10) is amongst the forest reserves leased by SAX from the Ghanaian government since 1996 for the extraction of tropical timber. MFR is one of three forest reserves inside FMU 10. The two other reserves within FMU 10 are Fure and Fure Headwaters. All three of the forest reserves derive their names from the main rivers that are flowing through them. MFR is the smallest and most northern of the three reserves. Because of its relatively small scale SAX currently gives priority to other reserves and has not yet operated within MFR.

2.1 Location and extent

2.1.1 Geographical location

MFR is situated in the Asankrangwa forest district, Wassa Amenfi district, Western Region, Ghana, West Africa (Fig. 2). The total Forest management unit lies between 5° 20' and 5° 42' northern latitude and between 2° 20' and 2° 26' western longitude. The North-eastern tip of MFR is entered by the Asankrangwa – Manso Amefi main road between border pillar 27 en 28. MFR has a fairly narrow shape and stretches around 15 kilometres from roughly north to south. Its width varies between 1.5 and 4 kilometres and it forms an almost continuous corridor between the forest reserves to the north and south only to be dissected by the main road in the far north (Fig. 3).

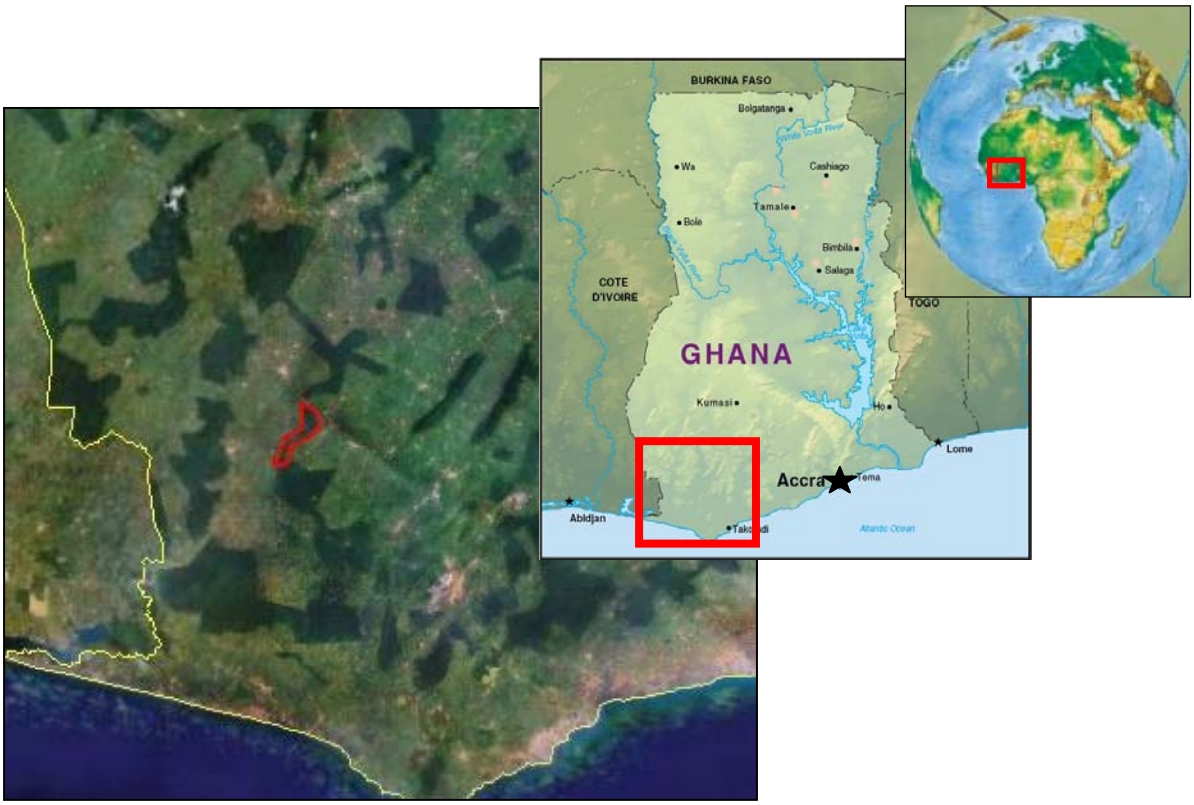

Fig. 2: Geographical location of MFR

2.1.2 Area and perimeter

The boundary lines of MFR are made of cut lines, roads, rivers and streams that have a total length of 49.3 km. The total area of MFR is roughly 45 km² (Fig. 3). 2,247 ha in the southern two thirds of the area is TPA. 2,283 ha in the northern third consist out of GSBA and FPA (Fig. 5). 2.31 ha is admitted farm and village land. The external boundary lines of FMU 10, including MFR, are fixed by border pillars that are placed approximately 800 meters apart from each other and at all directional changes. These boundary lines are usually not wider than 2 metres and quite often used as footpaths. They are kept clear by the FC to prevent encroachment. The reserve is divided into 41 compartments, which are generally all 128 Ha in size.

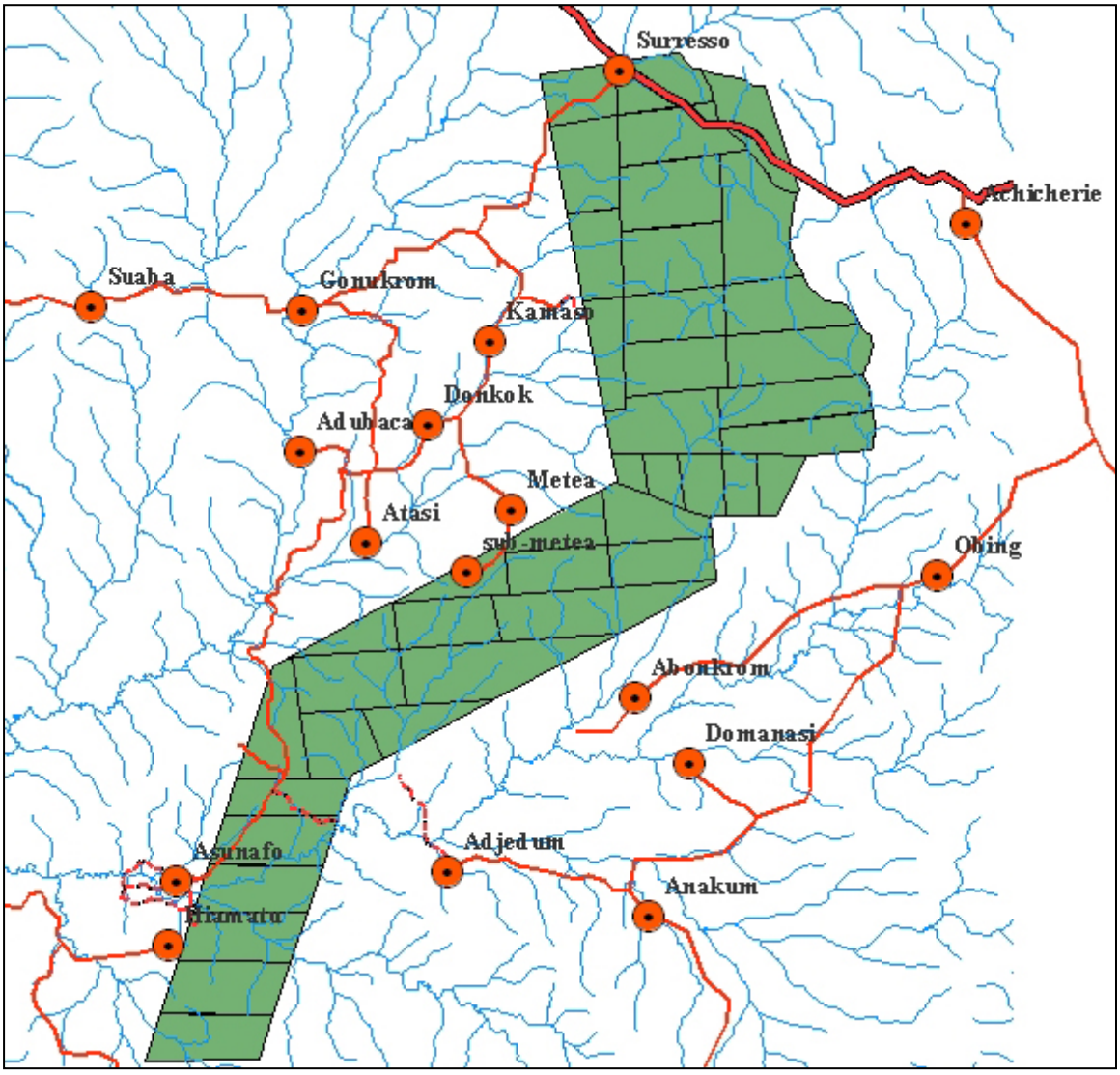

Fig. 3: MFR and surroundings

2.2 Ecological factors

2.2.1 Topography

The altitude within MFR varies between 90 metres in the south to 180 metres in the north. The area is generally gently undulating. The South of the reserve is relatively flat terrain and the north has hilly ground with steep hillsides and swamps. A large part of Samre river watershed lies within MFR boundaries. There are around 15 villages in the close vicinity of the reserve of which most are accessible by badly maintained dirt roads. The only sealed road runs east-west in the far north of the reserve.

2.2.2 Climate

Western Ghana and MFR have a tropical climate with two wet seasons a year. The mean annual temperature in MFR is 26-27 ˚C (Taken from FAO 2004). Rainfall in Ghana generally decreases from south to north. The wettest area is the extreme southwest (FAO 2004). According to the regional planning team (2005) the mean annual rainfall for the meteorological station closest to MFR (60km.) is 1446.13 mm. Winds during the wet season are predominantly south-west but in the dry season the wind is dominated by the north-east harmattan winds.

2.2.3 Geology

Most soils in Ghana are developed on thoroughly weathered parent materials. They are old and have been leached over a long period of time (FAO, 2004). The soils within the FMU are mainly Ochrosol/Oxisol integrates (Brammer in Regional planning team 2005).

Oxisols (ferric, Plinthic Acrisols FAO) are developed under green rain forest with rainfall above 1770mm (FAO 2001). Poor natural soil fertility, water logging in bottomlands and drought on shallow and/or skeletal Plinthosols are serious limitations (FAO 2001).
Ochrosols (Rhodic Ferralsol FAO) developed both forest and savanna environments under rainfalls between 900 and 1650mm (FAO 2001). If the process of “nutrient cycling” is interrupted, e.g. after introduction of low input sedentary subsistence farming, the root zone will rapidly become depleted of plant nutrients. Maintaining soil fertility by manuring, mulching and/or adequate (i.e. long enough) fallow periods and prevention of surface soil erosion are important management requirements (FAO 2001).

Jack (1953) states that the skeletal and immature soils on steep upper slopes are relatively frequent, and nearly all the upland soils in the north of MFR are highly acid, falling in the Oxisol group. He also states that the Samre and Mesama valleys in the southern two thirds of the reserve are associated with alluvial deposits (Kwaben series), and that Boi and Omappe series are found on the low hills in between these valleys. The north of the reserve and the higher parts of the remainder are well drained: the valleys named above are less so (Jack 1953).

2.2.4 Hydrology

Although about 70 percent of the total land area of Ghana is drained by the Volta river system, MFR is part of the south-western river system which comprises the Bia, Tano, Ankobra and Pra rivers and covers 22 percent of the country area (Taken from AQUASTAT, FAO 2005). The reserve is drained to the south by the tributaries of the Samre river that runs southwards (regional planning team 2001).

2.2.5 Vegetation

The southern half of MFR lies within the WE forest zone and the northern half is part of the ME forest zone. This is quite unique as MFR is one of the very little reserves that encompass the transition between the two forest zones. The two zones lie within the tropical lowland evergreen rain forest formation.

"*This is the most luxuriant of all plant communities. It is lofty, dense, evergreen forest 45 m or more tall, characterised by the large number of tree species that occur together. Gregarous dominants (consociations) are uncommon and usually two-thirds or more of the upper-canopy trees are of species individually not contributing more than 1 per cent of the total number. This formation is conventionally regarded as having three layers: the top layer of individual or grouped giant emergent trees, over a main stratum at about 24-36 m, and with smaller, shade dwelling trees below that. Ground vegetation is often sparse and mainly of small trees; herbs are patchy."* (Whitmore 1998)

2.3 Socio-economics

2.3.1 Population

In the beginning of the 19th century the indigenous Wassa Awowins and Wassa Fiases people were defeated by the Akwamu people who moved to the west. The state that the migrant Akwamus established was named after the vanquished people (Wassas) and suffixed the adjective "Amenfi" to it because their domain was in the mist of other states (Regional planning team 2001). The estimated number of inhabitants within a 2 kilometre radius from MFR is currently 5,000. An assumption made by the regional planning team in 2001 shows that the population in the area have increased by more than 50% in 16 years. They also indicated in the socio-economic survey of 1984 that almost half of people could be classified as migrants, having come into the area over the last 35 years to develop cocoa farms. The average population density in the western region is 48 ind./km. (FAO 2004)

2.3.2 Social organisation

In rural villages around MFR there is usually one village chief who makes key decisions together with the village elders. The traditional way of life is respected. Ancestral practises, beliefs, superstition and taboos are generally continued. This varies per family; Families within the same village may not have the same taboos.

Most families run farms on which they work with the whole family to earn a living. Cocoa farming is very popular and widespread. Virtually all families living around the reserve are in the business.

2.3.3 Landuse

The reserve itself is divided into 3 different categories. The northern half of the reserve consists of conservation areas GSBA and FPA (see Fig. 5). These areas should be protected and no road or track development and logging activities whatsoever are allowed here. Some NTFP extraction is allowed in the GSBA area but is strictly forbidden within the FPA. The southern part of the reserve is set aside as TPA which is slightly less than half of the total 4.533 ha. This area classification is a nationally implemented system, the different area classes are described in chapter 1.3.2. MFR consist only out of natural forest and does not encompass any plantation area at this moment. 2.31 ha within the reserve is admitted farm and village land. The surrounding off reserve areas is dominated by farms. Many of the farming practices include forest conversion to cocoa plantations or slash and burn systems. Healthy forest can not be found outside the reserve.

2.3.4 Agricultural activities

Farming activities are found all around the reserve, and in most cases right up to the forest boundary line. Cocoa is the main crops grown here but maize, cassava, yam and rice are also grown to a lesser extent. According to the regional planning team, two-thirds of the people in the area own up to 3 ha of farms. Hunting and trapping is very common within the reserve. Usually smaller animals like rats and cats are trapped with snares and larger animals like duikers and primates are shot with a shotgun. Gathering of foods such as snails, nuts, fruits and chewsticks, but also other NTFP’s, is very widespread. NTFP’s collection in MFR is practised by virtually all families living close to the reserve. Cattle breeding is practised very little in the area as mostly only goats are raised. Some zebus are present but their numbers are limited. Chickens and ducks are common. A few people have started to breed snails or rats taken from the wild.

2.3.5 Infrastructure

The North-eastern tip of MFR is entered by the Asankrangwa – Manso Amefi main tarmac road between border pillar 27 en 28. This is the only sealed road in the whole area and runs through the reserve for some 2 kilometres. The reserve is easily accessible as the main dirt road from Samreboi to Sureso also passes along the western boundary of the reserve and there are several villages around the outskirts of the reserve that are accessible by roads. Apart from the Asankrangwa – Manso Amefi and Samreboi – Sureso roads most other roads are in poor state. Electricity is limited to villages along these 2 main roads. Clean water is provided by water pumps in all of the larger villages. These were constructed around 10 years ago by an overseas organisation. Apart from the main sealed road in the north there is one other road within the boundaries of the reserve. This dirt road leads from Gonukrom to Asunafo

on the eastern side of the reserve. There are no railroads in the vicinity. The nearest airstrip is owned by SAX and located in Samreboi.

2.3.5 District administration

FMU 10, including MFR, lies within the political jurisdiction of Wassa Amenfi District Assembly which has its headquarters in Asankrangwa. The District Forest Manager (DFM) is responsible for its management. Execution of the management prescribed by the DFM is done by a Range Supervisor. Forest Guards support the Range Supervisor in the execution of this management. The workforce for MFR is one shared range supervisor with Fure Headwaters and 4 forest guards. Forest guards are usually locals living around the reserve. They keep a certain length of boundary line clear and prevent encroachment and illegal logging. Hunting or other illegal activities do not concern them.

2.3.6 Property rights

The central government has legal rights over the land and leases MFR as a concession to SAX. SAX has legal timber harvesting rights and is responsible for implementation of management issues given by the FC. In theory the DFM of the FC should supply SAX with adequate management plans regarding MFR and their other operational forest reserves. The FC acts as law enforcement and sees to it that illegal logging and encroachment is minimized. Ownership of the land lies with the stool of Akyekyere, a village on the North-eastern boundary of the reserve. Royalties are paid to the chief by SAX on a regular basis to be able to obtain harvesting rights. Communal rights to shooting, hunting, collecting snails or deadwood and rights to cultivate any area which was under cultivation since the time the rules of MFR came to force exist (Taken from Regional planning team 2001). In 2001 this changed partially with the designation of FPA's. Its strict conservation status does not allow extraction of any forest products by anyone. No mining rights within MFR are issued to anyone. However, SANKOFA gold mining company obtained a licence to carry on surface gold mining in the nearby off reserve area.

2.4 Forest management in Mamiri Forest Reserve (MFR)

2.4.1 Mamiri Forest Reserve (MFR) management before 2001

First documentation from MFR dates back to the 1920's and 1930's when limited selective logging of Mahogany (*Khaya ivorensis*) was executed. Logs were hauled over more than 3 km by hand. Trough 1941 to 1944 selections and demarcations were done within the forest reserve. In 1949 a slight boundary revision was carried out. The first management plan for MFR was written for the period of 1958 to 1963 and described selective felling and clear boundary maintenance. It provided land within the reserve that could be used for villages or Taungyas. Commercial NTFP collection was prohibited although historical records indicate that some permits were handed out for the collection of canes, Nsoko (chew sticks), oil or Raphia, palm, latex

and poles. All communities were allowed to collect NTFP's for domestic use but large scale illegal collection of Nsoko and plants for medicinal uses did (and does) occur as well.

In 1992 a 20 year management plan was made to replace the one from 1963. Goals were made more clear and aimed at an optimum and continuous production of wood and NTFP's. Increase the number of commercial species and promote their growth with Silviculture. Although aims were especially on production, the protecting role of the forest and the local communities need for NTFP's was taken into account. Some areas were designated as Hill Sanctuaries where no timber exploitation was allowed (Fig. 4). No further plans were made for the protection of biodiversity.

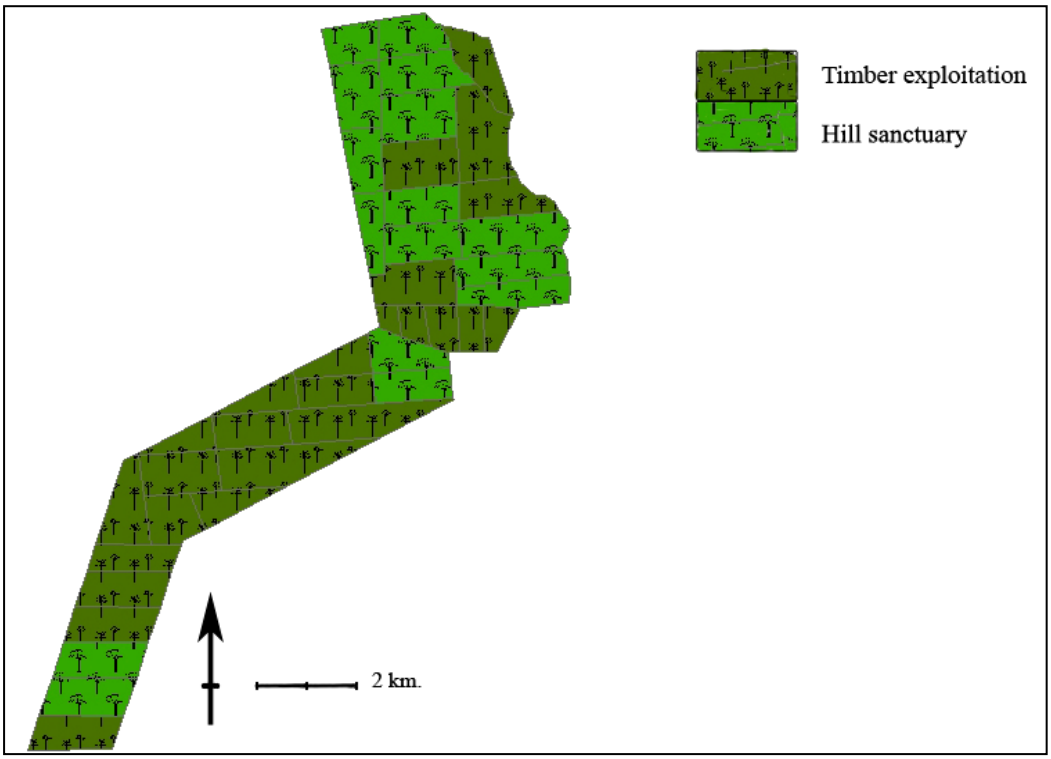

Fig. 4: Location of hill sanctuaries within MFR

One hectare sample plots were set out by the FC for permanent sampling to acquire data about the increment in stem diameter, basal area and standing volume, as well as regeneration capacity and mortality rates. These sample plots were to be re-measured every three years. In the 90's gathering of NTFP's by local communities for domestic use was still allowed but if they were to be used for commercial use a permit was needed and could be applied for at the FC. Illegal gathering of NTFP's for commercial use was still widespread and as a result Nsoko (chewsticks) was diminishing from the forest. Hunting within the forest reserves was not allowed, though full-time hunters were numerous.

2.4.2 Mamiri Forest Reserve (MFR) management after 2001

The present management is done with the use of the management plan that is drawn up by the FC's regional management team (2001). There is some emphasis put on conservation of biodiversity, while the southern part of the reserve is designated for timber exploitation. Because the present management plan does not go into detail on some of the desired issues SAX is planning to write their own management plans. They will have to be approved by the FC.
This management plan written for MFR should give more detailed information about the future management of the area and should prove that a timber production company like SAX is fully capable to write their own management plans.
In the latest management plan written by the FC's regional planning team in 2001 the former goals are reformulated and more attention is given to the conservation of biodiversity. Maintaining the protective role of the forest for watershed, protection and conservation of biodiversity was their main goal as well as sustained production of timber and forest product. To be able to accomplish these goals MFR was divided in different management zones (Fig. 5). Different management is applied in each zone.

The planning of logging operations within the forest reserve is done by the concessionaire and approved by the FC. As it is right now, harvesting of the compartments is scheduled in the following years:

2001-2005	1,2,3,4
2011-2015	37-41
2026-2030	28-36, 5

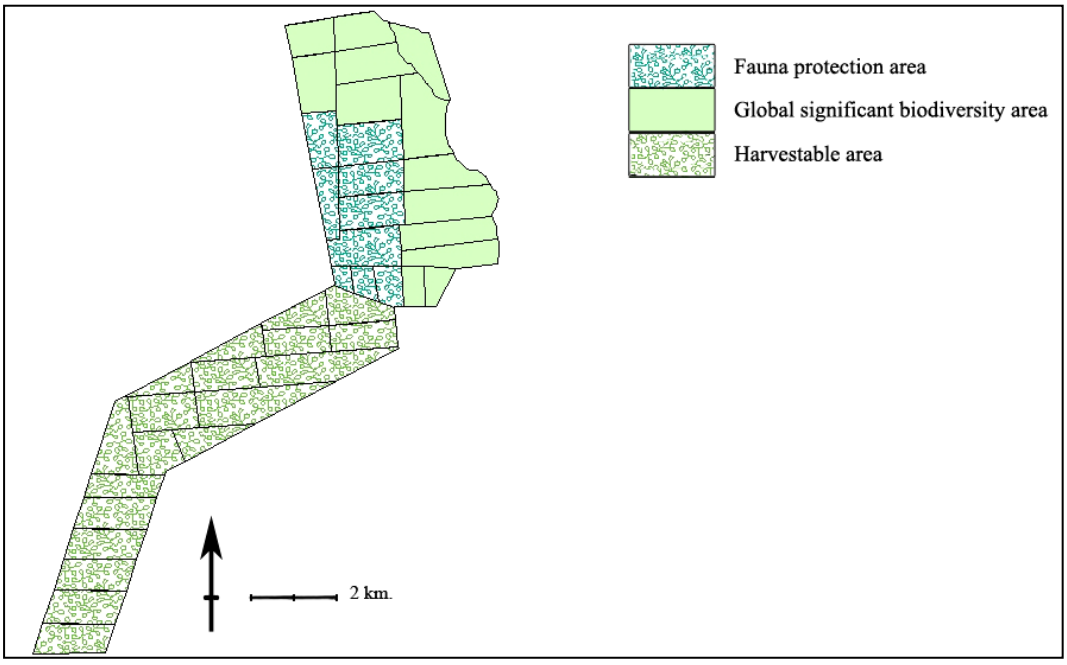

Fig. 5: Zonation of MFR

2.4.2.1 Past timber stock evaluations

The FC has conducted some research over the years and established PSP within MFR. Although some of the information could be found in the latest management plan there was no access to the database. SAX has enumerated several compartments in MFR in the recent past (Fig. 6).

The former management plan written by the FC's regional planning team (2001) reported that regeneration in MFR ranges from 300 to 600 seedlings per hectare. This number is most likely an estimation based on data taken from samples from which an average is calculated for the area. Still it is relatively low compared to the estimation of 3000 commercially interesting seedlings per hectare that was obtained during this project (Chapter 3.1.2). According to the regional planning team (2001) a total of 141 different species are recorded in MFR. Primary forest is well represented within the reserve. The distribution of stem numbers per diameter class is positive. For the trees in the lowest diameter class (30-49 cm), practically no records are made because these trees were not yet of interest for the next felling. There is supposed to be an increase in stem numbers in the lower diameter classes and decrease in the higher diameter classes. This is essential for a sustainable forest exploitation management. We can see that the first two classes stay behind in this.

According to the inventories done by SAX in 1997, in compartments 33, 34, 36 and 41, stocking of mature commercial species greater that 70 cm have an average of 7.7% for primary commercial species and 9.7% for secondary commercial species. A total of 71 different species were recorded in these four compartments.
In MFR, 9 commercial scarlet star species are present. Also 2 red star species and 1 pink star species are available. More detailed information about the stand is available from the compartments 33, 34, 36 and 41, in which an inventory has been done by SAX in the recent past. The Access database "Inventory data of comp 33, 34, 36 and 41" on the CD in the back of this document shows the full detailed inventory data.

Average tree volumes are known for the primary and secondary commercial species that are present within MFR. These can be multiplied by the number of stems that is above felling limits, averages are given in Table 4. Some timber species should be excluded from the yield, because their stem number is 5 or below per compartment. Table 5 shows the species that can be included in the yield calculations.

Calculating the harvestable number of stems from the inventory, using the formula given in chapter 1.5.1, we can conclude that average fellable volumes for scarlet star species is 3.6 cubic meter per hectare, for red star species this is 1,8 cubic meter per hectare and for pink star species this is 0.4 cubic meters per hectare. Averages are shown in the table 6.

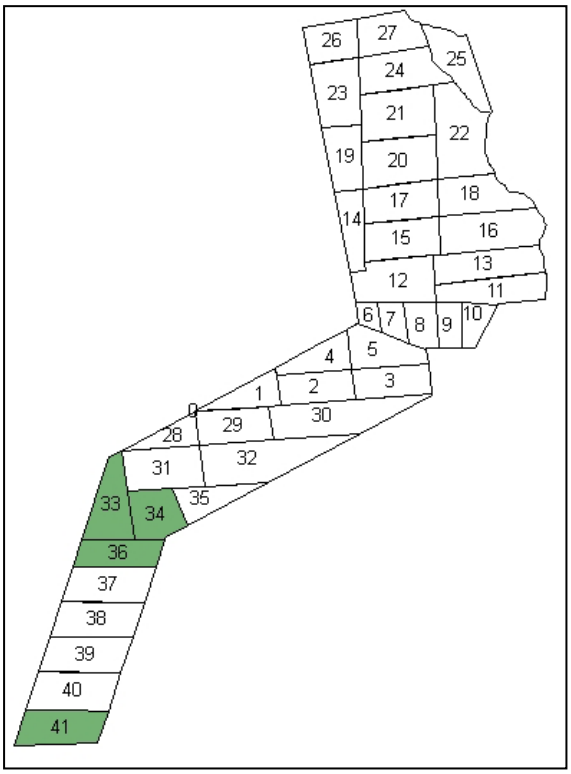

Fig. 6: Past inventory compartments

Species	*Av. fellable volume per ha*	*star rating*
Edinam	1.2	scarlet
Asanfena	0.0	scarlet
Sapele	1.6	scarlet
Mahogany	4.6	scarlet
Odum	0.5	scarlet
Makore	3.6	scarlet
Ceiba	7.1	red
Hyedua	0.7	scarlet
Kussia	3.0	scarlet
Emire	0.2	red
Wawa	4.0	scarlet
Ofram	0.7	pink
Pink star	0.7	
Red star	7.3	
Scarlet star	19.3	

Table4: Average fellable volume

Compartment	*Spp.*					
33	Mahogany	Ceiba	Hyedua	Kussia	Wawa	Ofram
34	Mahogany	Ceiba	Kussia	Wawa	Ofram	
36	Ceiba	Kussia	Emire	Wawa	Ofram	
41	Mahogany	Hyedua	Kussia	Wawa		

Table 5: Species suitable for felling

Species	*Average volume per ha*	*star rating*
Mahogany	1.1	scarlet
Ceiba	1.8	red
Hyedua	0.2	scarlet
Kussia	1.0	scarlet
Emire	0.1	red
Wawa	1.4	scarlet
Ofram	0.4	pink
Pink star	0.4	
Red star	1.8	
Scarlet star	3.6	

Table 6: Average fellable volume per hectare

Table 7 shows the harvestable volumes per compartment for the different species.

Harvestable volume (M^3)

Tree species	*Comp 33*	*Comp 34*	*Comp 36*	*Comp 41*
Mahogany	156,5	117,4		143,4
Ceiba	213,0	234,3	191,7	
Hyedua	41,7			52,1
Kussia	110,9	41,6	97,0	124,7
Emire			17,8	
Wawa	92,7	236,9	144,2	20,6
Ofram	63,3	40,3	34,5	11,5

Table 7: Volumes per compartment

For some of the most popular timber species the log prices are known. All timber prices are constantly fluctuating so the figures given here are a mere indication to show us if logging would be profitable at this point. Prices for sawed wood are significantly higher but even harder to predict.

Current log prices for
Mahogany: $52 to $110
Ceiba: $53 to $99
Wawa: $47 to $106

The costs for a logging operation are changing as much as timber prices and no stable amounts can be taken for this. As an indication we have taken the average of some different logging operations in different compartments. With this we can calculate how profitable it is to start a logging operation in the area at this moment (Table 8).

Road construction: $7724,58
Stumpage (inc royalties): $8512,87
Total: ***$16237,45***

Tree species	*Comp 33 min - max*		*Comp 34 min - max*		*Comp 36 min - max*		*Comp 41 min - max*	
Mahogany	-8100,49	975,35	-10134,73	-3327,85	-16237,45	-16237,5	-8778,57	-459,05
Ceiba	-4948,45	6958,25	-3819,55	6958,25	-6077,35	2740,85	-16237,5	-16237,5
Wawa	-11880,55	8873,95	-5103,15	8873,95	-9460,05	-952,25	-15269,3	-14053,9

Table 8: Minimum and maximum income per compartment

An overview of the data, processed into tables can be found in Appendix XVIII.

2.4.2.2 Wildlife inventory

In 2001 a wildlife inventory was held by the FC in most forest reserves in the western region. They concluded that MFR is still rich in wildlife and confirmed a population of chimpanzees (*Pan troglodytes)*. For the complete data gathered refer to Appendix VI.

2.4.3 Difficulties in management

- Although proposals were stated by the regional planning team (2001), most of them were not implemented. There is obviously a lack of resources. The actual management is done according to the Manual of Operations of SAX.

- Future management plans should be much more detailed and not only be written by the FC. SAX should be thoroughly involved during construction.

- No continuation of PSP data gathering done in the 80's by FC, most of the older data is not available now and the position of the PSP is unknown.

- Harvesting schedules obtained from SAX imply that MFR is first to be entered in 2011-2015 for felling in compartments 6-8,12 , 14, 15, 17, 19, 20.
  These are the exact compartments which form the FPA that was allocated by the regional management team 2001. Management of SAX is not aware of the existence of FPA's as they were never properly explained by the FC.

- The community is given the responsibility, along with the FC to enforce the laws concerning any entrance into FPA's. Local people haven't got any idea about position of FPA's so they will never be able to help.

- Forest guards that should be upholding the law on encroachment, commercial NTFP gathering and hunting, do their work only partly. Encroachment and commercial NTFP gathering is their main concern but hunting can be done freely. People know it is illegal but the chance of being caught is too low to prevent them from doing this.

- The pillars are placed by the FC and should be maintained by them. However it appears that the forest commission does not have the means to do this adequately and many of the boundary pillars are poorly maintained or missing.

- Previous management has been too focused on timber stock and NTFP's. Although protection areas were set aside no management was written for protection

2.5 Mamiri Forest Reserve History

Under English colonisation in the beginning of the 20th century the, then, Goldcoast government began to declare certain lands subject to forest reservation to be able to manage their natural resources. In the course of 1910 a Forest Ordinance was passed to empower the Governor to declare certain lands subject to forest reservation. But the Government did not dare implement the ordinance in the face of local opposition so that implementation was delayed untill1927 (Taylor in Parren & de Graaf, 1995).

The 1935 revised Forest Ordinance encouraged the reservation of forests, but its bylaws did not ensure management, and these were later replaced by rules which caused local authorities to manage their reserves in accordance with advice of the Forestry Department (Brrokman-Amissah in Parren & de Graaf, 1995).

MFR was selected and demarcated in 1941 and 1943/44 respectively. In 1949 a slight boundary revision was carried out. Mamiri forest reserve was constituted under the Wassa Confederacy Native Authority (Mamiri Forest Reserve) rules in 1949. dated October 26, 1949 which appeared in Gold Coast Gazette No. 56 of January 17, 1950 (Regional planning team 2001).

In 1948 African Timber & Plywood Company (AT&P) was the first timber company to lease the reserve for a period of 25 years. Although there has been some exploitation, the northern part remained relatively untouched.

In the early 70s, as a result of political conflict, all rights over their ancestral lands were stripped form the traditional communities and assumed by central government (Repetto in Parren & de Graaf 1995). Ownership of the land remained with the stool of Akyekyere.

Documentation of the regional planning team (2001) reads that when the lease to AT&P expired in 1973 the area remained unencumbered until 1997 when it was reallocated to Messrs. Samartex Timber and Plywood Company Limited for 40 years (15/12/1997 to 1/12/2037). Up to date no exploitation within MFR has taken place by SAX.

In the beginning of the 21st century the government has set out GSBA's and FPA's as an act to try and conserve biologically important areas within forest reserves. In the past the forest reserves were solely set apart for timber extraction. Now parts of the forest reserves are set aside for strict nature conservation. Forestry and wildlife issues were formerly divided into separate governmental administrations. They have concluded that forestry-, nature- as well as fauna protection management are related and go hand in hand. The two separate administrations have recently been combined to form the FC. Now the FC is trying to combine forestry and wildlife issues in joint management for their forest reserves.

3. State of forest resources

3.1 Vegetation

To be able to get information about the state of the forest and resources in terms of timber stand and vegetation within MFR Permanent Sample Plots (PSP's) can provide a lot of important data. In the past the FC has established some PSP's in every forest reserve. These should have been measured every few years to provide information about the stand and forest dynamics. Unfortunately monitoring of the PSP's that were established in MFR has somehow not continued. Information about the location of the former PSP's as well as their measurement data appears to be lost. For this reason new PSP's were established here.

3.1.1 Inventory methodology: Permanent Sample Plots

PSP's are demarcated square forest plots with a size of 100 by 100 metres. Within these plots all trees with a Diameter Reference Height (DRH) above 20 centimetres are measured every few years for monitoring purposes. The DRH can be defined as the stem diameter at a height of 1.30 meter or 30 centimetres above the buttresses. They provide detailed information on current forest structure, composition, stand volume, biodiversity, etc. and they will provide crucial information for future calculations concerning stand dynamics.

3.1.1.1 Positioning of new PSP´s

Since it was impossible to retrace old PSP's within MFR and previous data had gone lost, new PSP's had to be established. The first step was to determine where to establish these new PSP's. Positioning of the new PSP's amongst the forest reserve is essential for the provision of area representative data. Special conditions should be taken into account, such as swamps, steep slopes and areas with higher altitudes, to prevent that specific area endemic species and forest structures are not overlooked. The 9 PSP´s that were established are divided as evenly as possible amongst different biospheres and topographical differences. Accessibility for the enumeration team was also taken into account. Most PSP's are located within the WE zone to give statistical representative data (see fig. 7).

3.1.1.2 Establishment of new PSP´s

With Geographical Information Systems (GIS) software the geographical co-ordinates of the corners of the newly to establish PSP´s were determined. With these co-ordinates, a Global Positioning System (GPS) and a topography map their position was determined in the field by a demarcation team.
Until recently when the use of a GPS was not yet available this used to be done with compass bearings using reference points and a tie line. This is very time consuming and labour intensive so the use of a GPS is greatly appreciated here. The method described is a great improvement in ergonomic, economic and logistic point of view. Once a corner of a newly to establish PSP is reached a wooden stake is put in the

ground to mark its location. From here the head of the demarcation team will determine the magnetic bearings of the external boundary lines of the new PSP

(usually 0°-180° and 90°-270°). Standing with his back against the corner stake he will then guide a line cutter along the magnetic baring line. The line cutter will cut small saplings with a machete as well as remove all other vegetation except large trees and lianas. When 100 metres is completed they will make a 90° turn and start again. When all external boundary lines are completed this way wooden pegs are placed at 20 metre intervals along the perimeter of the PSP using a measuring tape. Influences of slopes on the area of the sample plot are not taken into account.

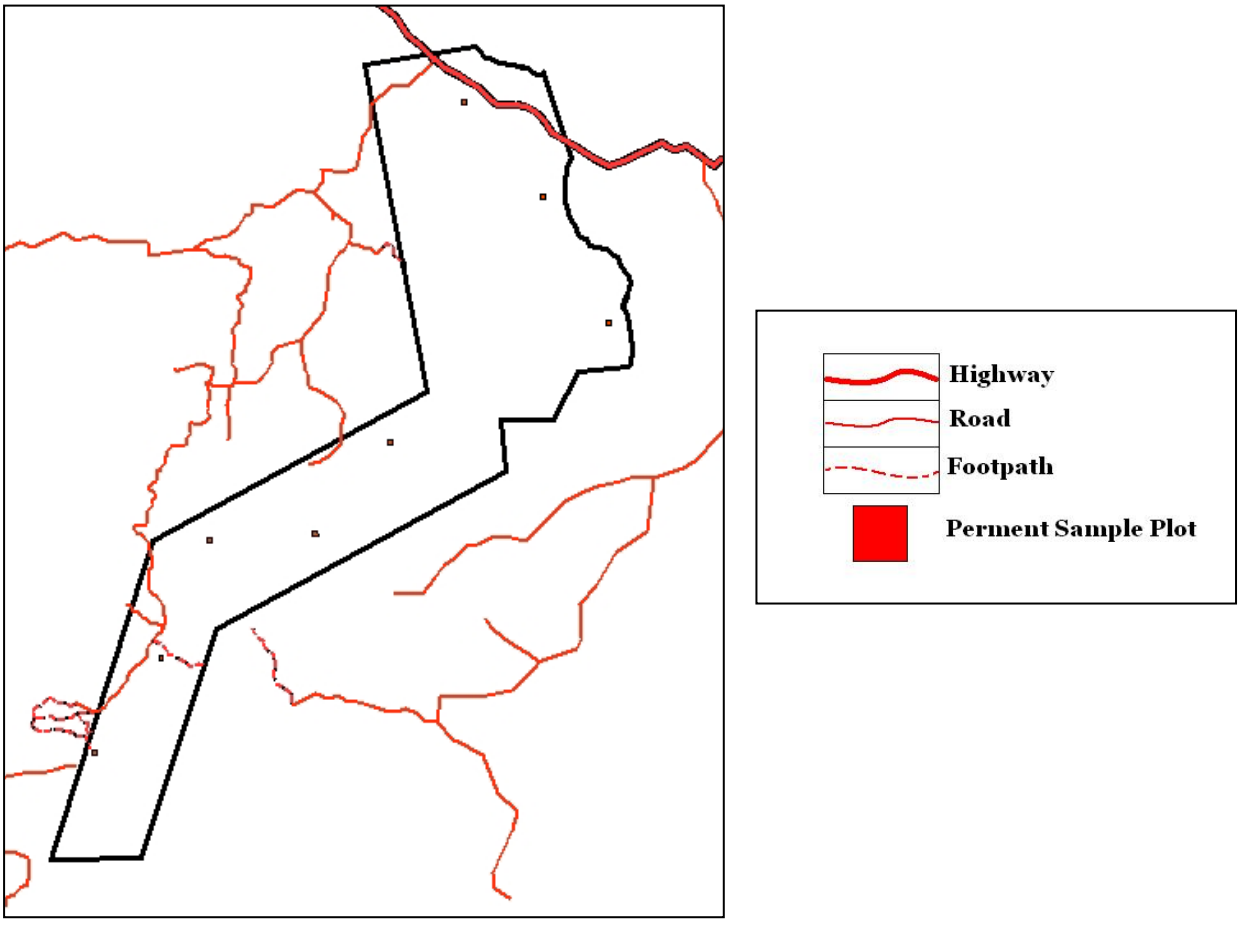

Fig. 7: Location of Permanent Sample Plots

When the perimeter is finished the internal or quadrate lines are cut starting from the 20 metre interval pegs. These quadrate lines are cleaned to a lesser extend by the line cutter; just enough to allow the inventory team to pass through easily. Within the PSP further disturbance of flora is not allowed so that natural processes remain undisturbed.
When demarcation is done, the four corners stakes will be marked with the PSP number and their position is pinpointed by GPS to confirm accurate position of the PSP with GIS. The end result will be a demarcated square of exactly 100 by 100 metre with 25 sub-plots of 20 by 20 metres (see Fig. 8). Enumeration of the plot can now begin.

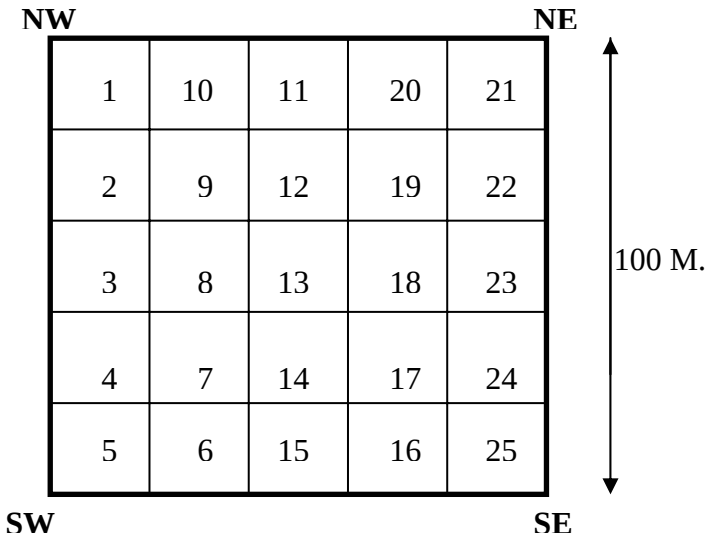

Fig. 8: Schematic layout of a PSP

3.1.1.3 Enumeration

After the PSP is demarcated well an enumeration team comes in to measure each tree with a DRH of 20 cm and up within each quadrate. They will also gather forest inventory data, namely: tree number, species, DRH, estimated height, crown form, crown position, degree of strangulation by climbers and presence of buttresses (see appendix XV). The enumeration of the different quadrates will follow the sequence as indicated in fig. 8, and each quadrate is worked in a systematic way to avoid missing any trees. In addition to enumeration of the larger trees regeneration within the plot is also measured with the use of temporary five by five meter subplots.

Within each PSP a regeneration plot of 5 by 5 metres was also set out. Using stakes a long measuring tape was put on the ground to form the boundary line. The plot was then divided into 4, or sometimes 8, smaller squares to make enumeration easier. In these plots all plants and trees up to a DRH of 20 cm were identified and counted. Species identification was done with the help of a highly experienced botanist and samples of unknown species were gathered and determined with the use of literature.

3.1.2 Results

Calculations made with the inventory data of regeneration plots indicate that 62,000 to 116,000 seedlings are present per hectare. Of this total 400 to 7200 seedlings of commercially interesting tree species are present per hectare. With an average of around 3000 seedlings per hectare a generous immature commercial timber stock is currently present. Though most of the commercially interesting seedling species are from a lesser commercial class, the number of seedlings from class 1 species is significantly lower, with an average of 178 seedlings per hectare (Table 9).

Plot # (5-5 m.)	*# of seedlings*		*Commercial Class I Spp.*	*Count*
1	280			
2	257		*Khaya ivorensis*	1
3	289			
4	155			
5	290			
6	128		*Entandrophragma angolense*	2
7	205			
8	215		*Khaya ivorensis*	1
9	204			
Average per plot (5-5 m.)	225		*Average per plot (5-5 m.)*	0.44
Average per hectare	89911		*Average per hectare*	178

Table 9: Average number of seedlings per hectare measured in regeneration plots

Within the 9 PSP's that were enumerated nearly 1700 trees with diameter above 20 centimetres were tagged and recorded. They represent a total of 137 tree species. 218 plant species were found within the regeneration plots, of which 42 were also tagged as bigger trees during the enumeration of the PSP's. When comparing plot 9 in the north -ME forest cover, hilly, 180m- with plot 1 in the south -WE forest, flat, 90m- we can see that there are some clear differences in species composition. Within PSP 9 62 different tree species can be found while PSP 5 counts 54 tree species. From this total only 28 tree species are found in both the areas. From the 137 present tree species only 13 species can be considered of real economical interest. Economical species can be divided into two classes; class 1, the prime economical species. And class 2, lesser economical species. This division is based on the market value of the species and lists can fluctuate according to market situations. Table 10 shows economic Class I and II species found within the PSP's in MFR.

Scientific name	*Local name*	*Class*
Aningeria spp.	Asanfena	I
Entandrophragma angolense	Edinam	I
Entandrophragma cylindricum	Sapele	I
Milicia excelsa	Odum	I
Heritiera utilis	Nyankom	I
Khaya ivorensis	Mahogany	I
Tieghemella heckelii	Makore	I
Ceiba pentandra	Ceiba	II
Terminalia ivorensis	Emire	II
Terminalia superba	Ofram	II
Triplochiton scleroxylon	Wawa	II
Daniellia ogea	Shedua	II
Nauclea diderrichii	Kussia	II

Table 10: Commercial lass I and II tree species found in PSP's

The stems can be subdivided into different diameter classes. Producing 5 different classes as can be seen in the following tables. In table 11 we can see that the presence of class 1 and 2 species in the higher diameter classes is very low. In the lowest diameter classes some more trees are present. These are some of the trees that have made it from the seedling bank to the next phase of their growth cycle. The next table shows the numbers of trees from non-commercial class species subdivided into diameter classes. Here we can see a positive stand table with a lot of "small" trees and decreasing stem numbers in the higher diameter classes as well. This is characteristic for climax species within a forest.

Diameter Class	*20-50*			*50-70*			*70-90*			*90-110*			*110+*		
Commercial Class	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
PSP 1	4		200	1		20			4		1	4	1		0
PSP 2	2		165			23			15			3			1
PSP 3	5	6	122		1	19	2	2	6			4	1	1	1
PSP 4	2	1	103			14		1	11			4			1
PSP 5	2		131	2		14	2		6	2		0	1		2
PSP 6	2	1	149	1	1	21	1		3		1	4			1
PSP 7	2		133	1		14			9			7			1
PSP 8	7	3	183			12			8			1	3		1
PSP 9	8	2	118	1		12		3	6	2		2	1		0
TOTALS	34	13	1304	6	2	149	5	6	68	4	2	29	7	1	8

Table 11: Diameter class distribution of Class I species in PSP's

Table 12 shows the totals of basal area and volumes that were found in the different one-hectare sample plots. We can see that there are some remarkable differences between the plots. For example plot 1 has a lower Basal area but a higher Volume than plot 2, which indicates a lower forest in plot 2, with a higher density of smaller trees. Appendix XVI shows the distribution of the different commercial class trees, their basal area and volume within the PSP's.

Plot no.	*Basal area m²*	*Volume m³*
1	14	291
2	17	186
3	19	205
4	17	178
5	12	127
6	17	212
7	14	220
8	18	191
9	21	457

Table 12: Basal area and volumes

Scientific name	Count
Dacryodes klaineana	158
Strombosia glaucescens	106
Allanblackia floribunda	83
Cola nitida	62
Turreathus africanus	60

Table 13: Predominant tree species within the PSP's

Star rating	Count
Black	9
Gold	5
Pink	31
Scarlet	21
Blue	11
Red	25
Total	102

Table 14: Star species in MFR

Some species are common in virtually all PSP's. Table 13 shows the five most common tree species. We can see that among the most common species, *Allanblackia floribunda* and *Cola nitida* are well presented. They are important economical tree species. *Allanblackia floribunda* is known as a timber tree but its seeds can also be used for soap and to make edible oil. *Cola nitida* has edible nuts that are chewed as stimulant by many local people. To a lesser significance is *Strombosia glaucescens*, it can be used for timber and its seeds contain oil that can be used as soap.

Fig. 9: Cola umbratella, a black star species. This specimen would be large enough to include in high impact decision making.

Some of these black star species were relatively abundant in several parts of the forest. In the 9 hectares that were enumerated 102 star species were recorded (Table 14). Nine of them were the significant black star, which has the highest GHI ranking. In which PSP's all of these star species were recorded can be found in Apendix XVII. Fig. 9 is a photograph taken in MFR and shows *Cola umbratella*, one of the black star species. This endemic species gets the highest GHI rating of 27 and no logging within 100 metres is allowed.

For each PSP the total GHI was calculated by counting the total star species within the plot that were encountered and multiplying them with their given GHI (Table 15). This is a quick way of assessing an area and determining which areas have highest diversity of rare plant species.

Plot	*GHI*
1	43
2	48
3	13
4	43
5	40
6	18
7	77
8	44
9	73

Table 15: GHI per PSP

In Table 16 we can see that plot 3 and 6 have a relatively low GHI, meaning that they are of least interest for conservation. Plot 1, 2, 4, 5 and 8 have an average GHI that lies between 40 and 48. The highest indices are found in plot 7 and 9, meaning that these are of most interest for conservation. Both of these plots lay in the north western part of MFR, which has always been under the protection of either hill sanctuaries or GSBA area. These high GHI values are due to the presence various Black star species; some of these species were abundant in most of the areas. Especially *Psychotria calceata* is abundant in the form of regeneration throughout most of the forest area.

The inventory data was noted on paper sheets in the field by the booker. This data was later transformed to a digital format. The data that was generated from this inventory is too extensive to show here and was put into an Access database that can be found on the CD provided in the back of this report.

3.2 Wildlife

There are various ways to be able to determine the status of wildlife populations within a forest reserve. Usually some sort of inventory has to be done, but because of the short timeframe this was going to be a problem for MFR and alternatives had to be sought. Local people such as hunters and gatherers that enter the forest have valuable information as to which animals they have encountered. Their knowledge can be used to get a quick assessment but however, estimations of population figures are impossible to determine this way. To be able to determine animal numbers and populations extensive research such as the line transect method could be applied but there was to short a time to be able to realise this here.

3.2.1 Field survey methodology

For MFR a wildlife survey was held among the local people inhabiting the surroundings of the reserve. The survey was commenced on the basis of a one on one interview with local hunters and gatherers. They were shown pictures of animals that are possibly present within the reserve and were questioned about them.

3.2.1.1 Preparation

First of all the goals and objectives were formulated (Appendix II) to be able to determine how to deal with things in detail during the survey. Afterwards further preparations could begin. Interview sheets with pictures of significant animal species

that could possibly be present within MFR were made before hand which would make it easy to recognize animals for the locals. The pictures were obtained through the internet. A complete list of the 32 animals used for the interviews, including detailed information, can be found in the extension material. The list is not at all complete and not intended to be. Only the most significantly important (vulnerable and endangered) and largest and most easily recognised species were chosen to be included for the survey. An extensive list of the total animal species that should be found in MFR can be found in Appendix V. While making these interview sheets the World Conservation Union (IUCN) red list and Convention on International Trade on Endangered Species (CITES) appendixes were used as a reference. From the IUCN red list all animal species that could possibly be present within MFR were taken, except for some rated as least concern. The most significantly important (vulnerable and endangered), largest and most easily recognised animal species were chosen to be included. Animals that are too small to be recognised or are considered very common were excluded. If the animals would be hard to identify the data would become too unreliable. Very widespread and common animals are not of great value for this research. One animal, *Kobus kob*, is included in the list as a liability test. This is an animal living in the savannah and definitely not present in MFR.

The description of animals that is shown in the extension material could also be very useful for the determination of unidentified animals that were seen inside forest reserves around western Ghana by, for example, timber stock enumeration teams. It must be mentioned however that the lists constructed by the IUCN are based on past research results. They are not always up to date and can only give data on species that are properly researched. It can never be really accurate. This is probably also the reason that some species are more represented in these lists compared to others (i.e. Bats and frogs).

After the preparation of the wildlife sheets GIS software was used to select local villages within a two kilometre range from the reserve. The locals in these villages within close proximity to the reserve were regarded to have the most interaction with MFR. Only those villages were going to take part in the survey (Fig. 10). First a casual visit was paid to all of these villages to get acquainted. After explaining our mission to the village chief all village elders were summoned and a meeting was held. Our mission was then explained to the village elders and all the bystanders. After some discussion an appropriate date was chosen for the survey to take place; a day on which most villagers would be around (generally on taboo days or on Sundays). This survey ran simultaneously with the NTFP survey described in chapter 3.3

3.2.1.2 Interviewing

After arriving at the pre arranged date a general meeting was held with the village elders and our mission was explained once again. General information about the villages itself was obtained during this first meeting and include information such as age of the town, total estimated inhabitants, totem species and taboo days. This information can be found in Appendix XIII. Totem species can vary per family, meaning that one family can hunt them while it is taboo for the other.

Hunters well know that it is prohibited to hunt some of the species that are present. Therefore they fear that they will be prosecuted when they give too much information. Because of this it is clearly explained to them that we are merely collecting information and that they should feel free to give us information.

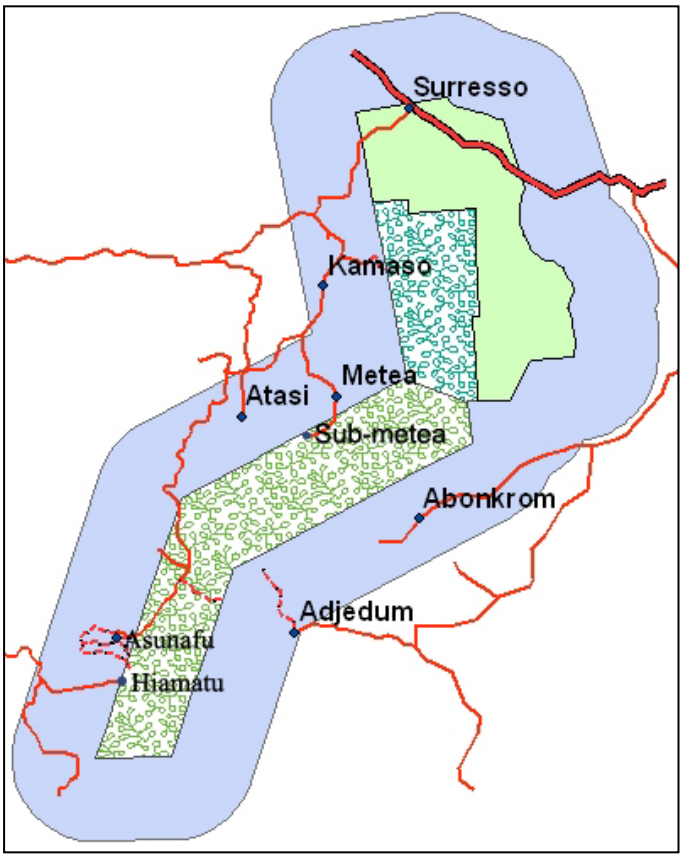

Fig. 10: Location of villages included in wildlife and NTFP survey

After selecting volunteers the hunters were asked to identify species by looking at the pictures. Animals were handled one by one. If they were able to identify the animal he or she was asked whether they thought it was common, uncommon or rare. They were also asked if they actively hunt the animal and if they thought the population is decreasing, stable or increasing. Any special remarks on the species were also noted. While taking the interviews, it became clear that not every hunter is equally capable of identifying species from a picture. Seemingly obvious different species often get mixed up so it is very important to make sure that the hunter takes his time while viewing the pictures.

This survey was integrated with the NTFP survey discussed in Chapter 3.3, and sometimes people would participate in both wildlife and NTFP survey. All villages were visited for a full day except Asunafo, Ayensukrom and Miwhede. Because of their relatively small size they were visited together in one day. At the end of the day a bottle of local Schnaps was given to the chief to prove our appreciation.

3.2.2 Results

In total 36 people were interviewed in 10 communities (see table 16). Almost all of the interviewees were hunters but occasionally a gatherer or forest guard was interviewed who was thought to have knowledge of wildlife. All data was noted on notation sheets that were also prepared before the interviews took place (see Appendix III). All collected data was digitised in an Access database and can be found on the CD in the back of this report.

Virtually all 32 surveyed animals are collected for either its meat or medicinal use. There is one exception: Demidoff's (dwarf) galago (*Galagoides demidoff*). Although it is killed sometimes it is the only animal believed to be increasing in population by the majority of the interviewees. During the interviews it also became evident that the flagship species chimpanzee (*Pan troglodytes)* still occurs in the northern part of the reserve. People in the northern villages regard it as common and virtually all hunters have seen them. Approximately half of the interviewed hunters indicate that they still actively hunt Chimpanzees. Larger primates are notoriously vulnerable to hunting, owing to both small population size and hunter preferences (Cowlishaw 2000).

Village	*inhabitants**	*# of interviewees*
Sureso	1000	4
Kamaso	800	7
Metea	300	2
Ataasi	150	2
Hiamatu	300	8
Agyedum	260	3
Abonkrom	400	3
Ayensukrom	30	1
Miwhede	150	2
Asunafo	560	4

Table 16: Number of wildlife survey interviews around Mamiri

This problem has recently been emphasised by Oates (1996b), who believes that the threat of habitat modification has been overestimated and that hunting within modified habitats is the key threat to many primate populations (Cowlishaw 2000).Virtually all other primates within MFR are also prone to hunting. Another flagship species, the Leopard, was rarely seen and only by predominantly the elder hunters. According to them it used to be common but it is currently most likely extinct but possibly still present in small numbers. The surveys taken in the different villages around MFR have concluded that most of the animal populations are decreasing. The hunters themselves notice that there is a steady decrease in animals that they encounter, but because of the need for proteins and the financial interest they stick to hunting. The most preferred species and the most commonly hunted species mentioned by the hunters are summarized in Table 17. Many of them are the larger mammals.

Most preferred species	*Presence*	*Most hunted species*	*Presence*
Maxwell's duiker	Common	Duiker species	Common
Brush tailed porcupine	Common	Brush tailed porcupine	Common
Monitor lizard	Common	Tree squirrel	Common
Water chevrotain	Rare	Bush rat	Common
Bush pig	Common	Mona monkey	Common

Table 17: Preferred and hunted wildlife species

3.3 Non-timber forest products

Non-timber forest products (NTFP's) are exploited by millions of people worldwide and contribute to their daily subsistence. A large variety of food and medicinal products are exploited, but also many other materials that are used for construction purposes, crafts and tools. Hunting and gathering within MFR is common and to some extend permitted but there is no clear view as to what quantities of natural resources are taken form the reserve. Parren (1995) states that NTFP's are collected in such variety and quantities, both for commercial and individual household purposes that, in terms of economic value, they may locally even outweigh that of timber.

3.3.1 Field survey methodology

To be able to get reliable NTFP information about MFR within a limited time span a survey with the use of interviews was chosen here. Information about the different NTFP's that are gathered in and around MFR was obtained by interviewing local people in all local villages within a 2-kilometre radius of the reserve (Fig. 10). They are the same villages that were visited for the wildlife interviews.

3.3.1.1 Preparations

First of all the goals and objectives were formulated (Appendix X) to be able to determine how to deal with things in detail during the survey. Than a casual visit was paid to all of the villages to get acquainted and explain our mission to the village elders. Then an appropriate date was chosen for the survey to take place; a day on which most villagers would be around (generally on taboo days or on Sundays). Notation sheets were also prepared to be able to accurately document the information. An example of the notation sheet that was used during the interviews can be found in Appendix XI. In fear of prosecution interviewees were somewhat reluctant to cooperate at first. Some herbalists also held back in fear of their recipes being stolen. Therefore it was decided that no detailed information should be taken about preparation and end use of the medicinal products and people should be able to remain anonymous if they do wish so. While taking the interviews, trust was gradually gained and increasingly more people wanted to be interviewed.

3.3.1.2 Interviewing

After arriving on the prearranged date our mission was explained once more and local herbalists and gatherers were approached and asked if they would want to take place in an interview. Interviews were held one on one but inevitable groups of bystanders were almost always present. Villagers were asked to mention the 2 most important NTFP's for each of the categories meats, fruits/oils, construction, tools, spices and medicinal uses. For each of the NTFP's named, there was asked whether it is gathered *on* and or *off* reserve. Furthermore, wherever possible, quantities gathered on a yearly basis were also requested. This proved quite difficult for the locals, as they hardly have any feeling for time and estimating quantities. Nevertheless, reasonable estimations could be made for the collection of animals (bush meats) and for young trees (poles) extracted for tools and construction purposes. It was also noted in what way harvesting takes place; whether it can be considered sustainable or not. If he or she sells any NTFP's on the local market traded quantities and market prices were requested wherever possible.

This survey was integrated with the wildlife survey discussed in Chapter 3.2 . All villages were visited for a full day except Asunafo, Ayensukrom and Miwhede. Because of their relatively small size they were visited together in one day.

3.3.2 Results

In total 39 people were interviewed in 10 communities (table 18)

Village	*inhabitants**	*# of interviewees*
Sureso	1000	9
Kamaso	800	4
Metea	300	2
Ataasi	150	5
Hiamatu	300	5
Agyedum	260	4
Abonkrom	400	4
Ayensukrom	30	1
Miwhede	150	2
Asunafo	560	4

Table 18: Number of NTFP survey interviews around MFR

In total 178 NTFP's were named by the local communities. A full list of these NTFP's can be found in Appendix XII. This list is by no means complete but merely all the species that were named by the locals here. Table 19 shows the 5 most important NTFP's in chronological order used by local people that were interviewed during the survey.

Scientific name	*Local name (Twi)*	*NTFP*	*Type*	*Use*
Achatina fulica	Ewa	Bush meat	Giant snail	Food
Piper guineense	Esurowisa	Pepper seeds	Climber	Spice
Cricetomis gambianus	Kussia	Bush meat	Bush rat	Food
Strombosia glaucescens	Afena	Poles	Tree	Construction
Dacryodes klaineana	Adwea	Fruit	Tree	Food

Table19: NTFP's that are most important to locals living around MFR

Snails (*Achatina fulica)*, Bush rat (*Cricetomis gambianus)* and Esurowisa seeds *(Piper guineense)* are predominantly collected in both on- and off-reserve areas. Afena (*Strombosia glaucescens*) and Adwae (*Dacryodes klaineana*) however are only found in on-reserve areas. Adwea fruits are collected in a sustainable manner without destroying the tree but whole Afena trees are cut for the use of construction wood (poles).

4. Conclusions

4.1 Vegetation

In the results of the PSP inventory (chapter 3.1.2) we can see that among the most common species *Allanblackia floribunda* and *Cola nitida* are well presented. This might very well be because these species are used commonly by the local people for their fruits. These species could be promoted by the local people to sustain their sources of income from the forest.

From the tree species found within MFR only a few can be counted among the commercially attractive species. Totals of the volumes can be found in Appendix XVI. A short overview of the volumes of the commercially attractive timber species found within the PSP's in MFR is shown in table 20. As the table is showing, we can conclude that timber extraction from MFR is not profitable at this moment. At least 15m3 per hectare is needed to make timber harvesting financially attractive.

Commercial class	*I*	*II*	*III*
Total m3	320	119	1628
Average m3/ha	11	10	181

Table 20: Average Volume (m3) per hectare in MFR

Although the data that was collected here is very valuable and gives us insight in available natural resources within the reserve, it is the first time that data was gathered as the PSP's were newly constructed. When a second inventory will take place in a few years this new data can be compared with the current data and even more valuable calculations can be made. Nine PSP's were planned and established during this project but more were actually desired. Because of the short time frame it was not possible to realise this here.

The data from the older inventories was used because these give a more complete view of the stand. The PSP data gives some information but the data acquired from the inventories is from the entire compartments, which gives a more precise view of the stock than the data that is gathered in the PSP's. This data can be used for annual increment, species richness, regeneration and mortality. But when you want information about the standing volumes, number of economic species and exploitability of the forest, extrapolating PSP data is far too inaccurate.

When looking at the inventory data that was gathered in some compartments by SAX, we can see that some compartments could be profitable if exploited. However, the maximum log prices should be assumed. But at this point it is not recommended to start logging activities in this region. The minimum income is way too low and chances are that a logging activity in one of these compartments would only cost money. The area would be very suitable for testing different silvicultural methods for species promotion. One of these silvicultural methods is described in chapter 5.2.

Tree species	*Comp 33 min – max ($ US)*		*Comp 34 min – max ($ US)*		*Comp 36 min – max ($ US)*		*Comp 41 min – max ($ US)*	
Mahogany	-8100	975	-10134	-3327	-16237	-16237	-8778	-459
Ceiba	-4948	6958	-3819	6958	-6077	2740	-16237	-16237
Wawa	-11880	8873	-5103	8873	-9460	-952	-15269	-14053

Table 21: Minimum and maximum income per compartment.

Some of the black star species were abundant throughout most of the forest, which raises questions about the actual rarity of these species.
One of the conservation measurements implemented by the FC is the restriction on logging within a vicinity of 100 meters near the Black star specimen. This would mean that much of the forest areas would be unsuitable for logging at all. From this point of view it might be better to take only the more developed specimens into these restrictions and leave the seedlings out of this decision because the life expectation of these is still too doubtful to include them into decisions that might have high impact consequences to the production of a logging organisation.

The GHI can vary a lot within a small area because black star species are not dispersed evenly throughout the forest. So when they are found within a regeneration plot of 25 m² it could very well be possible that these are the only ones within the area. On the other hand, when they are not found within the regeneration plots this will not mean that they are not present within the entire sample plot as well. To obtain a good view of the dispersion and abundance of Black star species, an inventory of the entire compartment would be needed. From this data a map could be made that indicates the Genetic hotspots in the area. There is not known as to what size requirements the tree must have to be able to be rated the star. Black star saplings have relatively little chance of survival.

The black stars we counted were basically only within the regeneration plots. Occasionally we would encounter one during the enumeration of the PSP, but we did not really look out for them. Therefore the total black stars that were encountered is by no means the actual total number of black star species within the PSP.

No logging because:

- Too little timber stock to be able to make reasonable profit (Table 21)
- Ideal site for Ecotourism
- Flagship species Chimpanzee present within the reserve
- Corridor for wildlife travelling between the two larger forest reserves to the north and south.
- Because of its narrow shape MFR is more likely affected more severely by local human influence and the edge effect than other larger reserves.

4.2 Wildlife

Interviewing for data collection purposes such as is done here could be considered unreliable in certain circumstances. However most of the interviewees that were interviewed here are sincerely friendly, helpful and knowledgeable about the forest and we dare to say that this information can be considered quite reliable.

The price a hunter can get for a duiker is about 150.000 to 200.000 Cedis (15-20 Euros), which makes it very lucrative to hunt. As seen in table 22 the hunters regard most species as common, but in addition they all stated that hunting was much more easily a few years ago, implying that populations have dropped over the years.

As in most tropical countries, the natural wildlife population is under heavy pressure from hunting and habitat destruction. In most forest reserves in Ghana hunting is illegal and GSBA's and FPA's are established that should keep people from hunting. When the former department of wildlife and the department of forestry were combined into the FC, the tasks of the forest guards were expanded towards hunting prevention. However, because most of the older forest guards were formerly under the authority of the department of forestry, they have little affinity and knowledge about wildlife. Their main concern is illegal logging and collection of larger quantities of NTFP's. Although hunters are well aware of the fact that hunting is illegal, they are not concerned about the forest guards and sometimes they even work side by side in forest border and footpath maintenance.

What came out of this survey is quite astounding; hunting is obviously a big problem within MFR. Virtually all questioned animal species are hunted and thought to be decreasing in population. Virtually every animal is collected for either its meat or medicinal use. There is one exception: Demidoff's (dwarf) galago (*Galagoides demidoff*). Although it is killed sometimes it is the only animal believed to be increasing in population by the majority of the interviewees. Some even think it is becoming a pest inside cocoa farms. There are relatively little hunters in Sureso compared to the other villages. This could be explained by the fact that Sureso is the biggest village and that it is located on the only main sealed road in the area. People do not depend so much on farming and hunting here because there are alternative employment opportunities.

When comparing the data collected by the FC in 2001 with the data collected here (Table 22) there was realized that the FC used virtually the same method of abundance rating. Therefore it is quite easily compared. However we do not know the exact method of data collection but we assume that it was also gathered by means of interviews. Many of the animals which have rare or vulnerable status are still regarded quite common within MFR. This makes MFR an important ecological area with the need for conservation and potential for ecotourism. Some species can have great importance and can even be vital to the preservation of the ecosystem. Wrangham, Chapman and Chapman (1994) found that although chimpanzees accounted for under 2% of the primate frugivore population in the Kibale Forest (Uganda), they accounted for 45% of all seeds defeceated by frugivorus primates (Cowlishaw, 2000).

English name	***Scientific name***	***IUCN category***	***CITES appendix***	***Research Mamiri***							
				Abundance rating							
				FC			SAX				
				C	UC	R	C	UC	R	Hunted	Population
Diana monkey	*Cercopithecus diana*	EN	I			x			x	y	↓
Chimpanzee	*Pan troglodytes*	EN	I		x		x			y/n	↓
King colobus	*Colobus polykomos*	NT	II						x	y	↓
Red colobus	*Procolobus badius*	EN	II			x			x	y	↓
G. black & white colobus	*Colobus vellerosus*	VU	Not listed			x			x	y	↓
Olive colobus	*Procolobus verus*	NT	II		x					y	↓
Collared mangabey	*Cercocebus torquatus*	NT	II			x			x	y	↓
Mona monkey	*Cercopithecus mona*	LC	II		x		x			y	↓
L. spot-nosed monkey	*Cercopithecus petaurista*	LC	II		x			x		y	↓
D. (dwarf) galago	*Galago(ides) demidoff*	LC	II		x		x			n	↑
Potto	*Perodicticus potto*	LC	II		x		x			y	↓
Yellow-backed duiker	*Cephalophus silvicultor*	Not listed	II			x			x	y	↓
Maxwell's duiker	*Cephalus maxwelli*	Not listed	Not listed	x			x			y	↓
Bongo	*Boocerus euryceros*	Not listed	III			x	x			y	↓
Bush buck	*Tragelaphus scriptus*	LC	Not listed		x		x			y	↓
(Dwarf) Forest buffalo	*Syncerus caffer nanus*	Not listed	Not listed			x			x	y	↓
Water chevrotain	*Hyemoschus aquaticus*	DD	III				x			y	↓
Kob	*Kobus kob*	LC	Not listed								
Giant forest hog	*Hylochoerus meinertzhageni*	LC	Not listed			x	x			y	↓
Leopard	*Panthera pardus*	LC	I			x			x	y/n	↓
A. golden cat	*Profelis aurata*	VU	II				x			y	↓
Giant pangolin	*Manis gigantea*	LC	II				x			y	↓
Long-tailed pangolin	*Manis tetradactyla*	LC	II				x			y	↓
Tree pangolin	*Manis tricuspis*	LC	II		x		x			y	↓
Pel's flying squirrel	*Anomalurus pelii*	NT	III		x		x			y	↓
Beecroft's tree hyrax	*Dendrohyrax dorsalis*	LC	Not listed		x		x			y	↓
A. brush tailed porcupine	*Atherurus africanus*	LC	Not listed		x		x			y	↓
A. dwarf crocodile	*Osteolaemus tetraspis*	VU	I		x		x			y	↓
A. sharp-nosed crocodile	*Crocodylus cataphractus*	DD	I					x		y	↓
Nile crocodile	*Crocodylus niloticus*	LC	II				x			y	↓
Nile monitor	*Varanus niloticus*	Not listed	II		x		x			y	↓
African rock python	*Python sebae*	Not listed	II		x		x			y/n	↓
Grey parrot	*Psittacus erithacus*	LC	II		x		x			y/n	↓
Rufous fishing owl	*Scotopelia ussheri*	EN	I				x			y	↓
Bare headed rock fowl	*Picathartes gymnocephalus*	VU	I				x			y	↓
White-breasted guineafowl	*Agelastes meleagrides*	VU	III					x		y	↓

Table 22: Overview of Wildlife survey research results in Mamiri.

If a more accurate list of species present within MFR is desired, an inventory with the use of transects could be done by well trained and experienced people. If more time would be available in the future some alternative inventory methods are described in Appendix VII. An explanation of the IUCN categories and CITES Appendixes shown in Table 22 can be found in Appendix IV.

4.2.1 Hunting versus captive breeding

Captive breeding of wild animals is a possible way to decrease the pressure on hunting. But this can only be done effectively when laws are properly enforced, risks for hunters are increased and more knowledge is handed out to farmers, in order to establish a working breeding program (see also Appendix VIII & IX).
If these measurements are not taken into account, the project will never have the aimed effects of decreasing the hunting pressure on wild animals.

4.3 Non timber forest products (NTFP's)

There is a seemingly endless list of more than 170 forest products coming from MFR that local people are using for many different purposes. This list is not complete, as it merely includes the 2 most important ones that people named per category. Most of the products are gathered in small quantities for own consumption and come from both on- and off-reserve. Products coming form plants or trees are mostly harvested sustainably (the vegetation is not destroyed but parts are harvested). There are some that might be over harvested though. They require more research to be able to determine this more accurately. Especially Giant snails (*Achatina fulica)*, Bush rat (*Cricetomis gambianus)* and the tree Afena (*Strombosia glaucescens)* require more attention. Giant snails are an easy catch and are gathered at will. Bush rats are trapped in snares and traps are numerous throughout the forest. Breeding of these animals is already introduced and should be further stimulated to reduce collection from the wild and ensure sustainability.
Afena is a tree species that cannot be found in off-reserve areas and is only harvested within the reserve (illegally). Small specimens are used as poles for construction purposes; the whole tree needs to be cut. Basically all houses in the region are built with this particular tree. The number of poles used per room and the number of rooms per household were questioned during the interviews. A calculation based on this information and the assumption that a room lasts for 25 years indicates that the average consumption per person per year is more than half an Afena tree. This concludes that the annual illegal harvest of Afena in MFR alone is more than 2300 trees. Whether this proves to be sustainable or not remains to be researched. However, it proves the importance of Afena and the species could possibly be grown on private lands or in village woodlots.

The forested area has decreased dramatically in Ghana over the past few decades and therefore local people have become more dependent on remaining forest reserves for the collection of forest products. The destruction of off reserve forests for farming and the increasing population pressure will almost certainly increase the exploitation of forest products by local people from remaining forest reserves, including MFR. Therefore adequate management is required to prevent over exploitation of forest products and depletion of forest resources. Much potential might lie in undiscovered species and could possibly have significant economical value. Many are unknown to the western world and may have potential to be introduced on the international market and to be grown in local agricultural systems. As Parren (1995) states, the economical value of NTFP's might locally outweigh that of timber.

5. Proposals for future management

5.1 Goals of forest reserve management for Mamiri

Considering its steep slopes, swampy areas, meagre timber stock and that only half of its size is suitable for exploitation SAX has no plans for timber exploitation within MFR in the near future. SAX realizes that exploitation of economical timber species is not economically sustainable on the long run and therefore it is looking for alternative income in the future. SAX now recognized its ecotourism potential and the site could be a good location for research experiments.

SAX should write its own FRMP's in the future and with close cooperation with the FC. Management issues should be described in more detail and they should be more adapted to the company's capabilities and desires. In contradict to the FC, SAX does have adequate resources to be able to write reliable, detailed and in depth FRMP's.

MFR could function as a test reserve, to do research on different aspects of forestry, nature conservation and forest exploitation (NTFP's and Eco-tourism). At the moment timber extraction in this forest reserve is not profitable, but it can be used to create and test a silvicultural system that would be suitable for the forest concessions of SAX. The general objective of the forest would be, to keep the selectively managed forest; this will conserve the ecologic value of the forest while promoting the growth of some economically attractive timber species. The aim is not to create a uniform forest, because this would be less favourable for the overall ecology, but to create a natural forest with a high percentage of economic species. The regeneration of some species, especially Mahogany (*Khaya ivorensis*) is very poor. This species is also enduring some problems when used in agro forestry or plantation projects. Therefore the natural regeneration should be promoted to satisfy the market demands for this timber species.

5.2 Exploitation

Because of its small size and meagre timber stock no timber exploitation should take place within MFR. Furthermore, it could be an ideal site to develop ecotourism, research and silvicultural experiments.

5.2.1 Promotion of lesser used species

At the moment a management is used that is based on the national AAC in combination with a forest condition evaluation, as described in chapter 1.5.1.2. After the allowed volumes are calculated and fellable trees are selected, only one tree species per compartment is extracted from the forest. After extraction of the desired trees, the compartment is closed and cannot be opened again until 40 years after the former logging.

The extraction of only one species from a forest is never sustainable because this will cause a gradual depletion of the regarded species from the forest. By repeatedly removing mature trees from a limited list of species, a gradual shift in the species composition in favour of the less desired species will take place in the course of time. This phenomenon is known as creaming and is a great concern of the Ghanaian FD at this moment. Therefore the AAC of *all* the tree species should be executed.

Most silvicultural systems that have been tried out were restricted to just a few species; often not more that 20 out of a potential number of over 100. Complex manoeuvres had to take place to make sure that the next felling series had an equally high yield. If more different species per compartment would be used for exploitation this could mean that lesser used species become more accepted on the marked. This can be the local market as well as the international market. To introduce lesser known species to the market, Parren and De Graaf (1995) mentioned the following requirements:

- A regular supply
- Heavy dimensions should be available
- The species should have suitable physical and technical properties
- The preferred end use of the species should be known
- Cost of the timber should be low, compared to traditionally accepted species

The availability of a regular supply can be required from national forest inventories. AAC can be calculated from this, which can be monitored with the use of PSP's. In Ghana it was found that only those species that had an abundance of at least one stem >70 cm DRH per square km and which were exported at least once since 1973 have export potential (Parren, de Graaf, 1995). This gives a clear indication of the market potential of timber species although some of these species are presently seen as lesser economically attractive species, or non-economical species. A list of these species can be found in Appendix XIX.

The end users need information about the physical, mechanical and chemical properties of the timber species. This data should be formulated in a uniform system so that they can be compared easily. Such a databank for lesser used species and their end uses has been developed by the Department of Forestry in Wageningen (Netherlands) on behalf of the International Tropical Timber Organisation (ITTO).

To achieve sustainable forestry with the use of more and different tree species consumers should be made aware that acceptance of "unknown" species may contribute to sustainable forest management. At this moment, lesser known species can be used at the carving section of SAX, as well as for some other uses, like in the veneer mill or as fuel wood in the steam turbines to provide electricity. However, this might prove not be very profitable.

The ITTO has produced a CD-rom with statistics of lesser used timber species, which can be used for the promotion of these species on the timber market.

5.2.2 Silviculture, the Ghana Selection System (GSS)

SAX is currently not applying any silvicultural systems in their concessions but they are interested in implementing any usable systems. Mamiri could be used to test silvicultural systems on a small scale in order to find out if any of these systems can be interesting on a large scale. The systems can be tested on a larger scale, which gives a more accurate view of the system than when it is used in only a few hectares.

Because in 1997 full inventories were made from the compartments 33, 34, 36 and 43, these would be the best areas for the testing of different silvicultural systems. A lot of information about these areas is available, which makes it easier to spot any changes that the implemented system would induce.

This system was critically assessed because of its supposed low annual increment, the poisoning of species that later on appeared of high economic value and the PSP data which was impossible to demonstrate. But the annual increment rates of sample plots, where improvement thinning was applied, did show an improvement of diameter increment from 0.2 cm per year to 0.6 cm per year (FPRI 1970). Also the required regeneration of different commercial species was obtained. In addition, annual costs were relatively low compared with other systems. This indicates that the system can be of great use, when it is managed and monitored well.

Following is a step by step description of the system as it can be tested in MFR. To avoid the problem with in the future potential economic species, the list of species classes from Appendix XIX is used.

Stock survey and Improvement thinning

To compile a stock map a stock survey should be done of all CAT I (Appendix XIX) species with a DRH of 70 cm and up. The exploitable trees will be selected on basis of the stock map in combination with the calculations mentioned in chapter 1.5.1 and the diameter limits that are used for the different tree species. This map should indicate merchantable trees as well as fruit bearing trees, which should be excluded from exploitation. This stock survey is done in combination with an improvement thinning of the stand, which should be in favour of CAT I species. To release the CAT I species with a diameter of 10 to 50 cm DRH, all CAT. III species and climbers within a radius of 4 meters should be cut or girdled. Beyond 4 meter, poor trees of CAT II, suppressing CAT I species are felled or girdled as well. Future trees that will be selected for promotion can be defined as CAT I species with a straight stem and a good vitality.

Records should be held for which tree is assisted. Regeneration should be recorded in PSP's to monitor species composition and forest dynamics. Often a climber cutting is done prior to a felling, in order to reduce felling damage and influences on the felling direction. Research (Parren, Bongers 1999) has proven that this has no significant impact on felling direction and absolutely no influence on gap size. Furthermore many Liana's play an important role in the ecology of the forest. Climber cutting will only be done to promote suppressed CAT I species.

Exploitation
When the selected trees for exploitation are indicated on the map, this should be approved by the FC and permit to fell the allowable yield should be given. Extraction of all species should be in relation to each other, dependant on the species composition within the present forest.
After exploitation the compartment is closed for extraction and the area can not be entered before a full 40 year cycle is completed.

5.2.2.1 in practice

It is advisable to experiment with the radius of tree felling that is used during the improvement thinning. Using a smaller radius will most likely produce a lower annual increment than when a larger radius is used, but operation costs will be lower as well. The radius of improvement thinning can be increased up to a point that the size of the radius has no influence on the increment anymore.

The system will be executed in the four different compartments where an inventory has taken place. In compartment 33 we will use the traditional system with an improvement thinning radius of four meters. This system should produce an annual increment of about 0.6 cm DRH. Costs should be about 3.7 man days per hectare per year. This would mean 392 man days per year for the entire compartment.

In compartment 34 the radius of the improvement thinning will be reduced to two meters, which should decrease the operation costs drastically but the annual increment should decrease as well. Although the radius is reduced to 50%, expected annual increment should not be linear connected. This is the same for the annual costs, which would expectedly drop to around 3 man days per hectare per annum.

In compartment 36 the radius should be expanded to 6 meters. This will increase the labour costs dramatically. Expected is that the annual increment will not increase much. The difference between the annual increment in compartment 33 and compartment 34 should be more than the difference between the annual increment in compartment 33 and compartment 36.

Example
The following is an example made for compartment 33 where an improvement thinning - radius of 4 meter is used. Inventory has already been done in 1997 so the following will not be the actual stock data but is meant to give an impression of the expected results. First of all a list of all the CAT I species present, and their stem numbers from 70 cm and up is made, as shown in Table 23.

From this table, the tree species that have more than 5 stems in the class just below felling limits are selected. For these species, the maximum felling limits are calculated, using the formula that is mentioned in chapter 1.5.1. This produces the data that is shown in Table 24.

Comp	Species	70-89	90-109	110-129	130-149	150+	Star rating
33	*Albizia zygia*	5	3	0	0	0	
	Anopyxis klaineana	7	5	5	0	0	Pink
	Antrocaryon micraster	2	2	0	0	0	Red
	Cynometra ananta	1	0	1	0	0	Pink
	Khaya ivorensis		0	22	15	0	Scarlet
	Nesogordonia papaverifera	4	1	0	0	0	Pink
	Parkia bicolor	35	23	18	3	0	Pink
	Piptadeniastrum africanum	94	63	23	3	0	Red
	Pycnanthus angolensis	38	15	1	0	0	Pink
	Terminalia superba	19	28	4	0	0	Pink
	Tieghemella heckelii		4	16	5	1	Scarlet
	Triplochiton scleroxylon		19	22	1	0	Scarlet

Table 23 : CAT I species in compartment 33

Tree species	Max. fellable stems	Star rating
Nesogordonia papaverifera	2	Pink
Parkia bicolor	21	Pink
Piptadeniastrum africanum	53	Red
Pycnanthus angolensis	19	Pink
Terminalia superba	11	Pink
Triplochiton scleroxylon	9	Scarlet

Table 24 : Maximum fellable stems of CAT I species

If we compare these stem numbers with the AAC for the different star ratings, we can conclude that it is possible to fell the maximum number of trees without crossing the restrictions for the different star ratings. On the average 1.1 stem per hectare will be felled in compartment 33. The total volumes that can be extracted from the forest at this moment are shown in table 25. In total, the extractable volume from compartment 33 is around the 12 m^3 per hectare. Improvement thinning should be executed in order to promote the trees that are selected for felling.

Tree species	Extractable volume(m^3)
Nesogordonia papaverifera	22
Parkia bicolor	226
Piptadeniastrum africanum	570
Pycnanthus angolensis	204
Terminalia superba	118
Triplochiton scleroxylon	97

Table 25: Extractable volumes

The increment rates of sample plots measured in 1970, which were treated with the GSS, showed an improvement of annual increment from 0.2 cm to 0.6 cm DRH (FPRI 1970). When we assume these rates to be similar for compartment 33, we can compare the untreated volumes with the volumes expected to be produced under this system. The national average mean tree volume calculated by the FC; 10.75 m³, is assumed here as well. This results in an increment percentage of 0.2% and 0.6%. The increment of volumes for compartment 33 in the untreated and treated state can be seen in table 26.

			Untreated		*Treated*
Tree species	*Stems*	*Present vol (m³)*	*Annual Increment (m³)*	*Present vol (m³)*	*Annual Increment (m³)*
Nesogordonia papaverifera	2	22	0,88	22	2,64
Parkia bicolor	21	226	9,04	226	27,12
Piptadeniastrum africanum	53	570	22,8	570	68,4
Pycnanthus angolensis	19	204	8,16	204	24,48
Terminalia superba	11	118	4,72	118	14,16
Triplochiton scleroxylon	9	97	3,88	97	11,64
Totals per hectare	1,4	15	0,60	15	1,79

Table 26 : Annual increment

Results from the different systems should produce data to find the most profitable rate between improvement thinning and labour costs.

5.2.3 Converted selection system

Poels & de Graaf,(1998) have found that most trees have a reasonable constant growth throughout their lifespan. But this constancy is very easily influenced by several factors. They also found that growth rate is boosted just after improvement treatment and that this boost is slowed down gradually over time, when competition has started again. Therefore we can assume that growth will remain more constant when a second improvement thinning is implemented after some years.

To test this, in compartment 41 the conventional GSS with an improvement thinning radius of 4 meters will be used in combination with the CAT I species shown in Appendix XIX. In addition a second improvement thinning will be implemented after 8 – 10 years, to suppress the regained competition. This system will highly increase and may even double labour costs. With the testing of this system we should be able to prove if this system is profitable.

5.3 Ecotourism

The general view on ecotourism from the public is one that is connected with experiencing wildlife and scenery while learning something about the natural history, ecology, biodiversity, exploitation etc. Today the number of ecotourism projects in developing countries increase rapidly. Travellers to developing countries increases nearly twice as much compared to travellers to industrial countries (Möller 2001). Many definitions on the word ecotourism exist but the International Ecotourism Society defines ecotourism as *"responsible travel to natural areas that conserves the environment and sustains the well-being of local people"*. Because the term ecotourism is often misused and the actual exploitation is not sustainable in any way, the Ecotourism Association of Australia and the Coöperative Research Centre for sustainable tourism have suggested some guidelines that an ecotourism product should meet up with:

1. Focus on giving visitors the opportunity to personally and directly experience nature (Natural area focus).
2. Opportunities to experience nature in ways that leads to greater understanding, appreciation, and enjoyment (Interpretation).
3. Represent best practice for environmentally sustainable tourism (Environmental sustainability practice).
4. Contribute directly to the conservation of natural areas (Contribution to conservation).
5. Provide ongoing contributions to the local community (Benefiting local communities.)
6. Be sensitive to, interpret and involve the culture/s existing in the area (Cultural respect).
7. Consistently meet consumer expectations (Customer satisfaction).
8. Be marketed and promoted honestly and accurately so that realistic expectations are formed (Responsible marketing).

Furthermore an area should have a high potential for ecotourism to make it a profitable investment. Sites with the greatest potential are sites that:

- Have an interesting wildlife that can be easily viewed.
- Have an ecosystem that is able to absorb a certain level of disturbance without being damaged.
- Are well accessible

Before starting an ecotourism project a well made Area Impact Study should be written to evaluate the impact on wildlife, sustainability, the natural benefits (e.g. education), soil, etc.

5.3.1 Potentials for Mamiri

MFR is located along the Asankrangwa – Manso Amefi highway and has good accessibility for tourists that travel between Takoradi and Kumasi. In addition it is only some 30 minutes driving from Samreboi, which will be the base for some Ecotourism lodges established by SAX in the near future.

The forest area is known to be home to a group of chimpanzees (*Pan troglodytes*), which makes the area very attractive for tourists. Although it will take effort to minimize hunting and getting the Chimps habituated and used to tourists it seems possible. Cowlishaw's results (2000) suggest that, although sample sizes were small, primates are more likely to habituate to the controlled presence of people than to leave the area. The area is said to have a diverse and, according to the local people, abundant wildlife. Some endangered bird species like the Bare headed rock fowl (*Picathartes gymnocephales*) and the White breasted guinea fowl (*Agelastes meleagrides*) are still present in this area. The most northern part has always been under protection of hill sanctuaries, GSBA or FPA. These areas have not been prone to logging for a long time and can be considered relatively undisturbed.
In the western part of the forest reserve, the Samre River runs from Sureso to Samreboi, which might possibly be an attractive route for canoe trips. The trips to Mamiri could be combined with several other interesting activities like visiting local markets. SAX has some very attractive facilities that could be used for tourism as well like the golf course and swimming pool. The company could even provide tourists with information about sustainable forestry and organise field trips to felling sites etc. Eventually the area could very well be used as a wildlife sanctuary, a safe place for wildlife that is under high pressure in so called "doomed habitats" or that are confiscated or caught off reserve and have no chance of survival in their present environment. Chimpanzees (*Pan troglodytes)* should be selected as flagship species for future ecotourism and conservation projects.

5.3.2 Preliminary research

The most important thing at this point in time is to conduct a market study on ecotourism in MFR and to determine whether it would be financially viable. Research should also be conducted to study the chimpanzee (*Pan troglodytes)* population and its viability to find out if an ecotourism project with chimpanzees as a flagship species is possible and will not harm the population. Assumptions can be made of the impact on the environment and what would be the maximum scale on which it would still be sustainable. The area should be well monitored so that environmental impacts can be
recorded, managed and minimized. The local people play a very large role in projects like these, because many of them rely totally on the forest for their income. With the implementation of an ecotourism project they will be forced to change their interaction with the forest. A survey should be done to get an overview of the vision that the local people have on SAX, ecotourism, and what they are willing to give up for this, and what they expect to receive out of such a project.

5.3.3 Awareness

An awareness campaign for the set up of such a project is crucial. All stakeholders will have to be approached and informed. The FC will have to be informed and cooperation should be requested. Local people will have to be made aware and tourists should be attracted.

5.3.3.1 Forestry Commision

With a detailed ecotourism plan the FC should be approached and permission and cooperation should be requested for implementation of the plan. Furthermore, they might be able to support the project during the awareness campaign amongst the local people. FC employees might have a more pronounced impact on people's opinion than SAX employees and their contribution could mean a great difference.

5.3.3.1 Local people

Local people have to be made aware of the personal interests that they will eventually have with stopping their destructive activities within the forest. In the end they will receive more benefits from the forest when they use it in a sustainable manner. The main problem is that people are looking for short term benefits; they will not look into the long term. Great effort will be needed to convince these people of their interests in sustainable forest exploitation. People should also be made aware of the tourist potential that MFR has and its financial benefits; e.g. hired guides, selling traditional art or local drinks and food, traditional homesteads etc. etc. (SAX could also think about funding villages surrounding MFR for not exploiting certain forest resources like Chimpanzees). An awareness campaign in surrounding villages is definitely needed. Employees of SAX, possibly with help of the FC, will have to go to the villages to arrange a meeting with the local chiefs to inform them about the potentials and tourism plans. The broadcast through a local radio station could be another good option to address a large population.

5.3.3.2 Tourists

One of the most important things to attract tourists would be advertisement. Tourists should be attracted to MFR for its rich vegetation, fauna, recreational and educational value. The best way to do this is to make travel agencies, travel guides, travel magazines, etc. aware of the various luxurious amenities in Samreboi and natural attractions in the surrounding areas. Information should be given to Travel guides (e.g. lonely planet, Bradt travel guide) by letters or e-mail. Information and brochures should be sent to Travel agencies and magazines. Another option could be the placement of articles in European and American magazines, informing about amenities and explaining the wide variety of ecologically sound activities that SAX is conducting.

5.3.4 Implementation

Although external help can be sought from outside (FC, funding from Nature organisations, NGO's etc.) SAX would be responsible for the implementation of the following steps. These steps were also put in an annual workplan (see Table 29). They are to be taken in chronological order:

- First of all tourist accommodation needs to be build. SAX has already made plans for the construction of bungalows on the riverside in Samreboi, they will be implemented soon.
- The FC should be approached and the plan presented. Help could be requested in the form of cooperation.
- Students, volunteers and researchers should be attracted to conduct important research within MFR like ecotourism market study, viability studies, social studies, etc.
- At least 2 local guides should be well trained, so they are able to deal with English speaking tourist. They could also be hired to habituate the Chimpanzees inside the reserve.
- A local taboo on the hunting and killing of Chimpanzees could be spread in an attempt to minimize hunting of the species.
- Local chiefs should be approached and the mission explained. Villages might be able to keep Chimpanzees from being poached against some small funding or other reward (e.g. village road grading)
- Trails should be set out to be able to organise guided forest tours.
- Brochures are to be designed and produced giving information on the amenities, MFR and showing pictures and maps with forest trails.
- Brochures are to be distributed amongst travel agencies.
- A website should be build dedicated primarily to the site MFR to attract tourist surfing the net.
- An information centre should be established in Sureso. Information about wildlife present in MFR can be put on display as well as a map of the area including forest trails. A local guide living close to the information centre can be hired permanently as housekeeper. He could take unannounced tourist not staying in Samreboi on guided walks if they do wish so. Some guided tours should be set up with this local guide. Ideal guides could be some of the hunters that know the area very well.
- A sign or billboard needs to be set up along the main Takoradi – Kumasi road.
- The northern area has some very steep slopes and high hills, which could be ideal to establish a canopy walk. This has been accomplished in Kakum NP (Fig. 11) with help of Canadian lumberjacks. It is a popular tourist attraction and it currently this is the only one on mainland Africa. A second one in MFR would be headline news. The canopy walk should be connected with trails and the information centre in Sureso.
- Once the tourists start coming, the local people should be stimulated to set up a stall to sell local handicrafts, arts, drinks, food, etc. to visitors.
- Eventually an airplane could be bought to bring in tourists by air. SAX's airstrip is currently not used but is still in very good condition.

Fig. 11: Canopy walkway in Kakum NP

Fig. 12 is an example of the area that could be used for ecotourism. The area should not be too large so that animals that are vulnerable to human visitors have the space to retreat in privacy. Tours should be planned in the early morning or late in the afternoon when there is the best chance to spot animals. The additional profit from this planning is that visitors are more interested in staying over in one of the ecotourism lodges that are established in Samreboi.

To minimize impact on the biodiversity, the cutting of vegetation for trail maintenance should be as limited as possible and should be stopped during migration and reproduction periods of the chimpanzees (*Pan troglodytes*). If hunting can be stopped period, former hunters that are chosen to be employed as guides can make regular visits to the chimpanzee (*Pan troglodytes*) colonies for habituation. This will make encounters for the future tourists more likely. According to Cowlishaw (2000) Chimps are more likely to habituate than to move away from the area. Guides should take only small groups into the forest, when searching for chimpanzees. Not only will this increase the chance of spotting other animal species because of the reduced noise, chimpanzees that are habituated to solitary guides or researchers can get very stressed from visits by groups. Even when groups are habituated to researchers, contact with large numbers of tourists can be highly stressful (Cowlishaw 2000). When tourists have close encounters with primates, some caution should be taken with the view on diseases. Many primate species are subject to human diseases and can react very strong on them. The most serious threat that tourism presents to primate populations, particularly where close proximity is involved, is disease transmission. Primates are highly vulnerable to disease epidemics and can easily contract human diseases (Cowlishaw 2000). Given the fact that the Chimpanzee population in MFR is relatively small makes them even more vulnerable. If new diseases appear that are unrecognised or untreatable, the results could be catastrophic in such small populations (Cowlishaw 2000).

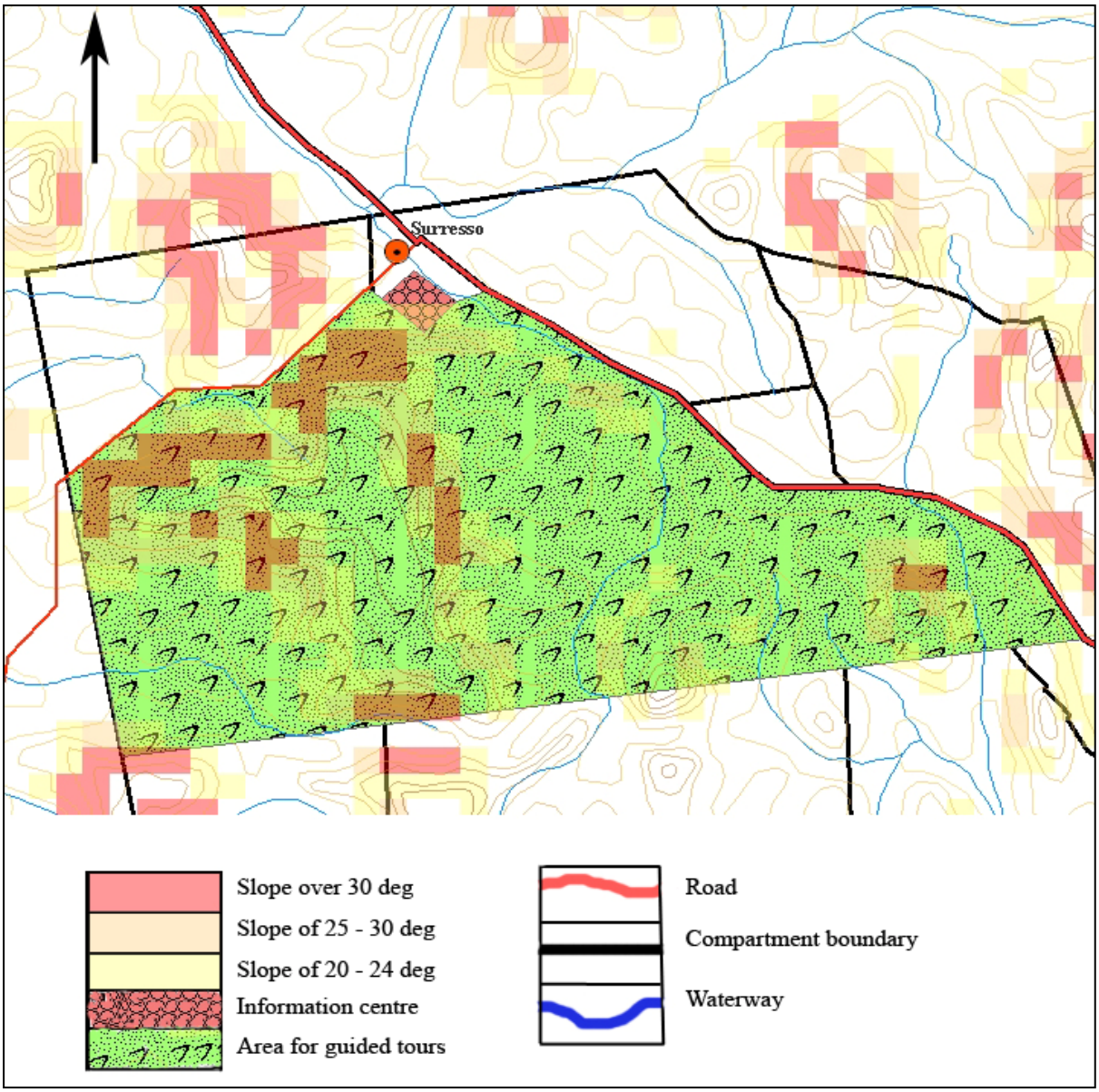

Fig. 12: Example of an ecotourism area

5.3.5 Funding

To start preliminary research, funding is needed as expenditures are inevitable far before any income from ecotourism is generated. SAX would be the main financer but help could be requested from the FC. Because chimpanzees (*Pan troglodytes)* are very appealing to many people, it should be considered a flagship species. Projects that are implemented to conserve flagship species have more chance of gaining funding when applied for by wildlife organisations. Funding could be applied for at many Nature organisations, NGO's or maybe even the government (FC). Researchers, students, volunteers could be attracted and invited to conduct research within MFR. This will be the cheapest way to gain crucial data for management purposes.

year	Activity	Initial investment Cost (EUR)
2007	Conduct market study on financial viability of ecotourism in MFR*	5,000
2007	Construct accommodation to house tourists (3x bungalow)	75,000
2007	Advertise and promote the site in magazines/travel guides etc.	100
2007	Train 2 carefully selected local people (hunters) as guides	1,000
2007	Production of a brochure with information and trail maps	2,000
2007	Distribution of brochure to travel agencies and hotels in the area	500
2008	Construction of Canopy walkway (500 m.)	50,000
2008	Hire 2 local guides (annually)**	500
2008	Set out predetermined forest walks on existing trails	200
2008	Construct information centre in Sureso	10,000
2008	Set up a sign on main road Takoradi-Kumasi***	1,000
2008	Conduct research to determine viability of chimps*	5,000
	total	200,300
	Unforeseen costs 15%	30045
	Grand total of initial investment	**180,345**

2008	Obtain small airplane (e.g. Cessna)****	50,000
2008	Hire Pilot (Annually)****	12,500
	Total of optional investments	**62,500**

* Help of students in preferred field could cut down on cost

** Depending on workload

*** Depending on regulations and cost government

**** 25 % of total; only percentage would be used for tourism

Table 27: Initial investment of ecotourism project MFR

As can be seen in Table 27, the initial investment needed for the set up of the ecotourism project proposed in this chapter is 180,345 Euros. This is excluded optional investments of the airplane and hiring a pilot. Of course this is merely an qualified estimation but it does emphasise that implementing such a project is very costly and will not pay itself back within a short period of time. Apart from the initial investment there are also annual costs like redemption and loans. Table 28 gives an example of the approximate costs that should be expected after the implementation of such a project.

	Annual costs
Activity	*Cost (EUR)*
Redemption tourist accomodation (5% annually)	3,750
Redemption canopy walkway (10% annually)	10,000
Redemption information centre Sureso (5% annually)	500
Advertise and promote the site in magazines/travel guides etc.	100
Update of brochure with information and trail maps	200
Distribution of brochure to travel agencies and hotels in the area	200
Hire 2 local guides (annually)*	500
Rent for a sign on main road Takoradi-Kumasi**	200
total	15,450
Unforeseen costs 15%	2317.5
Grand total of annual costs	**17,768**

Redemption airplane (10% annually)***	5,000
Hire pilot (annually)***	12,500
Total of optional annual costs	**17,500**

* Depending on workload

** Depending on regulations and cost government

*** 25 % of total; only percentage would be used for tourism

Table 28: Annual cost after initial investment of ecotourism project MFR

5.4 Conservation of the environment

MFR has unique wildlife of which many are vulnerable and endangered. It is also one of the very little forest reserves that encompass the transition zone from the ME forest zone to ME forest type. To be able to protect its flora and fauna adequate management has to be undertaken.

5.4.1 Conservation by religion

As in most parts of Ghana, the practice of traditional beliefs is very common. People have a strong belief in the several stories that are told about the forests and their spirits. This is very usable when trying to introduce and uphold new taboos in the forest. For instance, a story could be spread about forest spirits that become angry when specified animals are hunted. To have the best results, several persons in different places throughout a region should introduce a story like this. Preferably a reasonable status in mysticism should convince people of the story. In this way, local beliefs, taboos and superstitions could contribute in the conservation of a species. Especially keystone species, which play an important role in the ecology of the forest, are qualified for this kind of “conservation treatment”.

5.4.2 Regulation of illegal forest product extraction

People living around the reserve extract many forest products. There has to be determined whether this can be sustainable on the long run.

- Hunting should be prohibited in the entire area to protect wildlife, including several endangered primates, from local extinction and this regulation should be enforced more thoroughly than it is done at the moment. Oates in Cowlishaw (2000) points out once again that many primates thrive in secondary forest areas but none are known to cope with heavy hunting pressure.
- People should be made aware of the consequences that unsustainable practises like encroachment, illegal logging, hunting, illegal NTFP collection have.
- More law enforcement is needed to patrol around the reserves.
- Boundaries should be kept clear more accurately so that encroachment will get a smaller chance.
- More warning signs should be placed around the forest boundaries in the local people's language.
- The FC should be made aware of current problems and cooperation should be requested.

5.4.3 Promoting alternatives to Forest product extraction

Alternative food sources and income generation is the only way that local people will stop exploiting forest products unsustainably. Below are some alternatives that can be though about.

5.4.3.1 Domestication of wild animals

Hunting is generally easier, less costly and less time consuming than breeding wild life. This is why captive breeding hasn't taken place on a larger scale before. The costs for snares and bullets are much lower than the costs that are initially made for breeding. In addition, wildlife farming gives result on a long term, while hunting give immediate income. Therefore to support captive breeding the prices of breeding should be lower than hunting, or penalties should be raised to an amount that it is not attractive for hunters to take the risk of being caught. In many cases hunting will continue even when farmed animals are available, because of many different factors. Of which these are the most applicable to the Mamiri forest region. When wildlife is still abundant, hunting is a cheaper way to get meat. Farmed animals are often seen as an insurance or saving, instead of being a protein source that can be used regularly. Long term planning can be difficult to introduce within some communities.

Small scale farming wild animals is one of the easiest ways to provide local populations in their need for proteins. This is already introduced on small scale in some of the communities in Western Ghana. The breeding of cane rats/grasscutters (*Thryonomis swinderianus)*, bush rats (*Rattus fuscipes*) and giant snails (*Achatina spp.*) are becoming more and more common ways to provide meat for consumption.

This alone is an exception on the global trend in the breeding of wild animals for consumption. In Appendix VIII an overview is given of the different aspects that have to be taken into account when breeding wild animals. Farmers should be made aware of the fact that the availability of proteins from hunting is dropping and in the end it would be more lucrative to produce meat by farming, than by hunting. Using small livestock, like guinea fouls, small ungulates and rodents can keep investment costs relatively low. These species are efficient with resources and can be partly fed with waste crops. Because they have a fast growth rate they have a relatively fast return of capital. In Appendix IX, some guidelines are given to the breeding of duiker species in captivity. Awareness campaigns and demonstrations should be held to further promote domestication and breeding of wild animals.

To put more pressure on hunting, forest guards should be trained to be more alert to illegal hunting and higher fines could be introduced for better maintenance of the law. An additional method to disencourage hunters is the raise of taxes on gun shells.

5.4.3.2 Domestication of important plant and tree species

Apart from domestication of animals local people could also be stimulated to grow important plant and tree species to reduce impact on MFR. If they would be able to set up successful small scale plantations of species that are commonly used they could provide their family with a steady supply of sustainable produced products. They could possibly even sell some of it and gain alternative income.

Promoting growth of timber species like Afena (*Strombosia glaucescens*) on private lands and possibly even village woodlots would be something to look into. Afena is used by virtually all locals for construction material and the extraction of the species might possibly be unsustainable. Even for trade by SAX growth of products like Thaumatin (*Thaumatococcus daniellii)*, Ashanti pepper (*Piper guineense)* also seem promising, even on the international market. SAX is already collecting large amounts of Thaumatin fruits from local markets for the production of a product that can be used as an alternative for sugar. Locals can be stimulated to plant Thaumatin on private lands. SAX can buy the fruits from them and supply them with alternative income. A similar system might be possible for Ahsanti pepper. Both species are shade tolerant and could possibly be very well grown under cocoa plantations.

Once again an awareness campaign could be set up to inform the locals about the potentials. Experiments should be conducted by SAX to determine what would be the best conditions to grow products like these. Courses and demonstrations could then be given to the locals about how to set up such a system. To further stimulate the locals in participating in such project SAX could even provide free seeds or seedlings.

5.5 Research

Researchers from different organisations could be invited to conduct their work on wildlife and vegetation in MFR. This will certainly put Mamiri on the map as a research and conservation area, which in turn attracts more researchers and donators. Research can also be conducted by students or volunteers, this will reduce costs

dramatically but has the disadvantage that there should be someone present that is familiar with the subject and it is not always certain that the results are satisfactory. One of the first studies with highest priority would be a market study to see if ecotourism would be possible and profitable in MFR.

5.6 Annual workplan

Year	*Aim*	*Activity*
2007	Conduct detailed market study on ecotourism.	hiring eco tourism expert
	Make locals aware of sustainable NTFP use	Starting information campaign in villages
	Conservation of Chimpanzee	Spread taboo on hunting chimpanzees Approach Forestry Commission explain plans and ask for cooperation
	Establish relations with local chiefs	Approach local chiefs
	Attract researchers	Contact universities
	Build tourist awareness	Writing to travel guides start building website.
	Improve accesibility	Clear airstrip for future flights to Samreboi
2008	Preparation for ecotourism	Setup a detailed tourism plan Train local hunters to function as guides Establish tourist map and trails Finish tourist accomodation Start building information centre Start building canopy walk Start habituation of Chimps Buying small airplane
	Start silvicultural parctices	Inventory of comp 33, 34, 36 and 41 Selection of harvestable future trees Improvement thinning of saplings and seedlings
2009	Start actual ecotourism	Hire local guides permanently start tourist tours Start tours for felling and exploitation
	Monitoring forest growth	Second PSP inventory
2012	Monitoring forest growth	Third PSP inventory
2016	Second silvicultural activities	Inventory of comp 41 Improvement thinning of selected future trees in comp. 41
2048	Completion of silvicultural research	Inventory of comp. 33, 34, 36 and 41 Felling of selected trees Selection of harvestable future trees Improvement thinning of saplings and seedlings

Table 29: Annual workplan

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